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INVESTIGATION OF THE DEVELOPMENT OF LAMINAR BOUNDARY-LAYER INSTABILITIES ALONG A SHARP CONE

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Measurements of mean-flow and fluctuating-flow parameters were made in the boundary layer on a sharp 7-deg cone in an investigation of the stability of laminar boundary layers. The flow fluctuation measurements were made using hot-wire anemometry techniques. Flow-field profiles and model surface conditions were also measured. The testing was performed at a free-stream Mach number of 8 for free-stream Unit Reynolds numbers of 1.0-, 2.0-, and 3.0-million per foot. The test equipment and techniques and the data acquisition and reduction procedures are described. Analysis of the hot-wire anemometer data is beyond the scope of this report.

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Investigation of the Development of Laminar Boundary-Layer Instabilities Along a Sharp Cone

CONTENTS

ILLUSTRATIONS

NOMENCLATURE

ALPHA	Angle of attack, deg
CONFIG	Model configuration designation
CURRENT	Anemometer heating current, mamp
DATA TYPE	Code indicating nature of data tabulated:
	SURFACE HEAT TRANSFER - Cold wall model surface heat-transfer measurements
	"2" - Model surface pressure and temperature measurements
	"4" - Mean boundary-layer profile measurements using pitot pressure and total temperature probes
	"6" - Probe flow calibration data
	"9" - Quantitative hot-wire anemometer data at particular point locations within a survey or within the free stream
DEL	Boundary-layer total thickness, in.
DEL*	Boundary-layer displacement thickness, in.
DEL**	Boundary-layer momentum thickness, in.
DITTD	Enthalpy difference at boundary-layer thickness, DEL, ITTD-ITWL, Btu/lbm
DITTL	Local enthalpy difference, ITTL-ITWL, Btu/lbm
EBAR	Anemometer mean voltage, mv
ERMS	Anemometer output rms voltage, mv rms
ETA	Effective total-temperature probe recovery factor ETA=(TTLU-T)/(TT-T) or (TTTU-T)/(TT-T)
HT(TT)	Heat-transfer coefficient based on TT, QDOT/(TT-TW) Btu/ft^2-sec-^{o}R
ITT	Enthalpy based on TT, Btu/lbm

ITTD	Enthalpy based on TTD, Btu/lbm
ITTL	Enthalpy based on TTL, Btu/lbm
ITW	Enthalpy based on TW, Btu/lbm
ITWL	Enthalpy based on TWL, Btu/lbm
LRE	Local unit Reynolds number, $in.^{-1}$
LRED	Unit Reynolds number at the boundary-layer thickness, DEL, $in.^{-1}$
LRET	Local "normal shock" unit Reynolds number (based on MUTTL), $in.^{-1}$
LRETA	"Normal shock" Unit Reynolds number at the anemometer location (based on MUTTL), $in.^{-1}$
LRETD	"Normal shock" unit Reynolds number at boundary-layer thickness, DEL (based on MUTTD), $in.^{-1}$
M, MACH	Free-stream Mach number
MA	Mach number interpolated to the anemometer location
MD	Local Mach number at boundary-layer thickness, DEL, $in.^{-1}$
ME	Mach number at boundary-layer edge
ML	Local Mach number
MU	Dynamic viscosity based on T, lbf-sec/ft^2
MUTD	Dynamic viscosity based on TD, lbf-sec/ft^2
MUTL	Dynamic viscosity based on TL, lbf-sec/ft^2
MUTT	Dynamic viscosity based on TT, lbf-sec/ft^2
MUTTD	Dynamic viscosity based on TTD, lbf-sec/ft^2

MUTTL	Dynamic viscosity based on TTL, lbf-sec/ft^2
P	Free-stream static pressure, psia
PHI	Roll angle, deg
POINT	Data point number
PP	Probe pitot pressure, psia
PPD	Pitot pressure at boundary-layer thickness, DEL, psia
PPE	Pitot pressure at boundary-layer edge, psia
PT	Tunnel stilling chamber pressure, psia
PT2	Free-stream total pressure downstream of a normal shock wave, psia
PW	Model surface pressure, psia
PWL	Model wall static pressure used for boundary-layer survey calculations, psia
Q	Free-stream dynamic pressure, psia
QDOT	Heat-transfer rate, Btu/ft^2-sec
RE	Free-stream unit Reynolds number, in.$^{-1}$
RE/FT	Free-stream unit Reynolds number, ft^{-1}
RETD	Local "normal shock" Reynolds number based on total temperature probe thermocouple diameter and viscosity of MUTTL
RHO	Free-stream density, lbm/ft^3
RHOD	Density at boundary-layer thickness, DEL, lbm/ft^3
RHOL	Local density, lbm/ft^3
RHOUD	(RHOD) * (UD), lbm/sec-ft^2
RN	Model nose radius, in.

RUN	Data set identification number
S	Curvilinear surface distance from model stagnation point, in.
SD PW	Model wall pressure standard deviation
SD TW	Model wall temperature standard deviation
ST(TT)	Stanton number based on stilling chamber temperature (TT), $ST(TT) = \frac{QDOT}{(RHO)(V)(ITT-ITW)}$
T	Free-stream static temperature, °R, or °F
TAP	Pressure orifice identification number
T/C	Identification number of model surface thermocouples
TCXXX	Identification number of thermocouples on model interior surface
TD	Static temperature at boundary-layer thickness, DEL, °R
TDRK	Temperature of Druck probe transducer, °F
THETA	Peripheral angle on the model measured from ray on model top, positive clockwise when looking upstream, deg
TL	Local static temperature, °R
TRAKE	Temperature of survey probe rake, °R
TT	Tunnel stilling chamber temperature, °R, or °F
TTA	Local total temperature interpolated to the anemometer location, °R
TTD	Total temperature at boundary-layer edge thickness, DEL, °R
TTE	Total temperature at boundary-layer edge, °R

TTL	Local total temperature, °R
TTLU	Uncorrected (measured) probe recovery temperature, interpolated at ZP, °R
TTTU	Uncorrected (measured) probe recovery temperature, in free stream, °R
TW	Coax gage surface temperature, °R
TWL	Model wall temperature used for boundary-layer survey calculations, °R
UD	Local velocity component parallel to model surface at boundary-layer thickness, DEL, ft/sec
UE	Local velocity component parallel to model surface at boundary-layer edge, ft/sec
UL	Local velocity component parallel to model surface, ft/sec
V	Free-stream velocity, ft/sec
X	Axial location measured from virtual apex of cone model, in.
XC	Calculated X location of survey station, in.
XSTA	Nominal X location of survey station, in.
ZA	Anemometer probe height, distance to probe centerline along normal to model surface, in.
ZP	Pitot-pressure probe height, distance to probe centerline along normal to model surface, in.
ZT	Total-temperature probe height, distance to probe centerline along normal to model surface, in.

1.0 INTRODUCTION

The work reported herein was performed by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 61102F, Control Number 2307, at the request of Air Force Wright Aeronautical Laboratory (AFWAL/FIMG) and AEDC Directorate of Aerospace Flight Dynamics Test (AEDC/DOF). The AFWAL program manager was Kenneth F. Stetson and the AEDC/DOF program manager was Elton R. Thompson. The results were obtained by Calspan Corporation/AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennessee, 37389. The test was performed in the von Karman Gas Dynamics Facility (VKF) Hypersonic Wind Tunnel (B) on February 12-15, 1985, under the AEDC Project Number CD06VB (Calspan Project Number V--B-OG).

This test was the fifth in a series of studies designed to investigate the development of laminar boundary-layer instabilities on sharp and blunt cones in hypersonic flow (Refs. 1-4). The present investigation extended the studies into the region of initial development of the instabilities, that is, near the apex of the sharp cone. Boundary-layer and free-stream flow-field data were obtained using hot-wire anemometer-, total temperature-, and pitot pressure-probes. Model surface pressure and temperature distributions, as well as cold-wall surface heat-transfer measurements were obtained. The model configuration was a 7-deg (half-angle) cone with a sharp nosetip (0.0015- in. radius) only. The test was conducted at unit Reynolds numbers of 1.0-, 2.0-, and 3.0-million per foot and angles-of-attack of zero and -4 degrees with an equilibrium wall temperature ratio (TW/TT) of approximately 0.82.

Inquiries to obtain copies of the test data should be directed to AEDC/DOF, Arnold Air Force Station, Tennessee 37389. A microfilm record has been retained in the VKF at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

Tunnel B (Fig. 1) is a closed circuit hypersonic wind tunnel with a 50-in.-diam test section. Two axisymmetric contoured nozzles are available to provide Mach numbers of 6 and 8, and the tunnel may be operated continuously over a range of pressure levels from 20 to 300 psia at Mach number 6, and 50 to 900 psia at Mach number 8, with air supplied by the VKF main compressor plant. Stagnation temperatures sufficient to avoid air liquefaction in the test section (up to 1350°R) are obtained through the use of a natural gas fired combustion heater. The entire tunnel (throat, nozzle, test section, and diffuser) is cooled by integral, external water jackets. The tunnel is equipped with a model injection system, which allows removal of the model from the test

section while the tunnel remains in operation.

2.2 TEST ARTICLE

The basic LUBARD model (fabricated by AEDC) was used for this investigation as well as for the previous tests (Refs. 1-4). The model was a stainless-steel, seven-degree half-angle cone of 40-in. virtual length and 9.823-in. base diameter featuring interchangeable nose sections (Fig. 2). In the present study, a nominally sharp nose of 0.0015-in. radius was used.

The model was instrumented with 24 pressure orifices and 30 surface thermocouple gages. Table 1 lists the instrumentation locations and indicates that the top centerline (THETA = 0) of the model was the main ray of pressure instrumentation, and the bottom centerline (THETA = 180 deg) was the only ray instrumented with thermocouple gages. Pressure orifices were also installed on the THETA = 180 and 270 deg rays at three additional axial stations. A model installation photograph is presented in Fig. 3.

2.3 FLOW-FIELD SURVEY MECHANISM

Surveys of the flow field were made using a retractable survey system (X-Z Survey Mechanism) designed and fabricated by AEDC. This mechanism makes it possible to change survey probes while the tunnel remains in operation. The mechanism is housed in an air lock immediately above a port in the top of the Tunnel B test section. Access to the test section is through a 40-in.-long by 4-in.-wide opening which can be sealed by a pneumatically operated door when the mechanism is retracted. Separate drive motors are provided to (1) insert the mechanism into the test section or retract it into the housing, (2) position the mechanism at any desired axial station over a range of 35 in., and (3) survey a flow field of approximately 10-in. depth. A pneumatically-operated shield was provided to protect the probes during injection and retraction through the tunnel boundary layer, during changes in tunnel conditions, and at times when the probes were not in use.

The probes required for flow-field survey measurements are rake-mounted on the X-Z mechanism at the foot of a strut that is extended or retracted to accomplish the survey. The direction of the survey with respect to the vertical is fixed by manually sweeping the strut to the selected angle between 5 deg (swept upstream) and -15 deg (swept downstream) and locking the strut in position.

A sketch of the survey probe rake is shown in Fig. 4. The top and rear surfaces of the rake are designed to mate to the strut of the X-Z Survey Mechanism. The rake is provided with four 0.10-in. I.D. tubes through which are mounted the hot-wire anemometer-, the pitot pressure-, and total temperature probes. The fourth tube was used in the present test for housing a thermocouple to monitor the rake temperature. The

tubes were slotted to accommodate spring clips attached to the rake which were used to hold the probes in position.

2.4 FLOW-FIELD SURVEY PROBES

The hot-wire anemometer probes (Fig. 5a) were fabricated by the VKF. Platinum-10% rhodium wires, drawn by the Wollaston process, of 20- or 50-micro-inch nominal diameter and approximately 150 diameters length, were attached to sharpened 3-mil nickel wire supports using a bonding technique developed by Philco-Ford Corporation (Ref. 5). The wire supports were inserted in an alumina cylinder of 0.032-in. diameter and 0.25-in. length, which was, in turn, cemented to an alumina cylinder of 0.093-in. diameter and 3.0-in. length that carried the hot-wire leads through the probe holder of the survey mechanism.

The pitot pressure probe (Fig. 5b) had a cylindrical tip of 0.006-in. inside diameter. This probe was fabricated by cold-drawing a stainless steel tube through a set of wire-drawing dies until the desired inside diameter was obtained. The outside surface of the drawn tube was subsequently electropolished to a diameter of 0.012 in. to minimize interference with the flow field surveyed.

The unshielded total temperature probe was fabricated from a length of sheathed thermocouple wire (0.020-in. O.D.) with two 0.004-in. diameter wires. The wires were bared for a length of about 0.015 in. and a thermocouple junction of approximately 0.005-in. diameter was made. Details of this probe are shown in Fig. 5c.

2.5 TEST INSTRUMENTATION

2.5.1 Standard Instrumentation

The measuring devices, recording devices, and calibration methods for all parameters measured during this test are listed in Table 2. Also, Table 2 identifies the standard wind tunnel instruments and measuring techniques used to define test parameters such as the model attitude, the model surface pressure, probe positions, and probe measurements. Additional special instrumentation used in support of this test effort is discussed in the following subsections.

2.5.2 Model Surface Instrumentation

Thirty coaxial surface thermocouple gages (0.125-in. diam) were used to measure the cone surface temperature. The coax gage consists of an electrically insulated Chromel® center enclosed in a cylindrical Constantan® sleeve. After assembly and installation in the model, the gage materials were blended together with a file and fine sandpaper creating a thermal and electrical contact in a thin layer at the surface

of the gage. A complete description and the data reduction procedure for this gage can be found in Refs. 6 and 7. The recording and calibrating procedures are summarized in Table 2.

Eighteen surface pressure taps were located along the zero ray of the model. Four additional taps were located on the 180-deg ray and three taps on the 270-deg ray. These taps, having approximate diameters of 0.062-in., were connected by tubing either to Druck® or Electronic Scanning Pressure (ESP) transducers.

2.3.3 Hot-Wire Anemometry

Flow fluctuation measurements were made using hot-wire anemometry techniques. Constant-current hot-wire anemometer instrumentation with auxiliary electronic equipment was furnished by AEDC. The anemometer current control (Philco-Ford Model ADP-13) which supplies the heating current to the sensor is capable of maintaining the current at any one of 15 preset levels individually selected using push-button switches. The anemometer amplifier (Philco-Ford Model ADP-12), which amplifies the wire-response signal, contains the circuits required to compensate the signal electronically for thermal lag which is a characteristic of the finite heat capacity of the wire. A square-wave generator (Shapiro/Edwards Model G-50) was used in determining the time constant of the sensor whenever required. The sensor heating current and mean voltage were fed to autoranging digital voltmeters for a visual display of these parameters and to a Bell and Howell model VR3700B magnetic tape machine and to the tunnel data system for recording. The sensor response a-c voltage was fed to an oscilloscope for visual display of the raw signal and to a wave analyzer (Hewlett-Packard Model 8553B/8552B) for visual display of the spectra of the fluctuating signal and was recorded on magnetic tape for subsequent analysis by AEDC. A detailed description of the hot-wire anemometer instrumentation is given in Ref. 8.

The a-c response signal from the hot-wire anemometer was recorded using the Bell and Howell Model VR3700B magnetic tape machine in the FM-WBII mode. This channel, when properly calibrated and adjusted, has a signal-to-noise ratio of 35 db for a 1.000 volt rms output and a frequency response of +1 to -3 db over a frequency range of 0 to 500 kHz. A sine wave generator is used to check each channel at several discrete frequencies, using an rms-voltmeter which is periodically checked on 1, 10, and 100 volt ranges. The sensor heating current and mean voltage signals from the hot-wire anemometer were also tape-recorded using the FM-WBI mode. Magnetic tape recordings were made at a tape speed of 120 in./sec.

2.5.4 Pitot Probe Pressure Instrumentation

Pitot probe pressures were measured during surveys of the model boundary layer using a 15-psid Druck transducer calibrated for 10-psid full scale. The small size of the pitot probe adjacent to the orifice

(Section 2.4) was characterized by time delays for the stabilization of the pressure level within the probe tubing between orifice and transducer, when the probe was moved across the boundary layer. In order to reduce this lag time, the pitot pressure transducer was housed in a water-cooled package attached to the trailing edge of the strut on which the probe rake was mounted (Section 2.3). The distance between orifice and transducer was approximately 18 in. The resultant lag time was of the order of one second.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS AND PROCEDURES

A summary of the nominal test conditions is given below.

M	PT, psia	TT, °R	V, ft/sec	Q, psia	T, °R	P, psia	RE/FT x 10^{-6}
7.94	220	1280	3775	1.04	94.0	0.024	1.05
7.98	440	1315	3827	2.04	95.7	0.046	1.99
8.00	675	1330	3850	3.10	96.4	0.069	2.98

A summary of the present testing is presented in Tables 3 and 4 together with that of each of the four previous efforts, which are documented in Refs. 1-4. This table provides a complete summary of the various types of measurements made with each configuration for the five tests. The individual tests may be identified by RUN numbers. For Ref. 1, RUN $<$ 200; for Ref. 2, 200 $<$ RUN $<$ 300; Ref. 3, 300 $<$ RUN $<$ 400; Ref. 4, 400 $<$ RUN $<$ 500; and for the present testing, RUN $>$ 500.

In the continuous flow Tunnel B, the model is mounted on a sting support mechanism in an installation tank directly underneath the tunnel test section. The tank is separated from the tunnel by a pair of fairing doors and a safety door. When closed, the fairing doors, except for a slot for the pitch sector, cover the opening to the tank and the safety door seals the tunnel from the tank area. After the model is prepared for a data run, the personnel access door to the installation tank is closed, the tank is vented to the tunnel flow, the safety and fairing doors are opened, the model is injected into the airstream, and the fairing doors are closed. After the data are obtained, the model is retracted into the tank and the sequence is reversed with the tank being vented to atmosphere to allow access to the model in preparation for the next run. The sequence is repeated for each configuration change.

Probes mounted to the X-Z mechanism are deployed for measurements by the following sequence of operations: the air lock is closed, secured over the mechanism, and evacuated; and the access door to the tunnel test section is opened. The various drive systems (see Section 2.3) are used to inject the probes into the test section and position the probes at a designated survey station along the length of the model, the shield

protecting the probes is raised, exposing them to the flow, and the flow field is traversed in the direction normal to the model surface to the probe height (or heights) selected for measurements. When the traverse has been concluded, the shield is closed over the probes and the mechanism is repositioned along the model. When the surveys are completed or when a probe is to be replaced, the X-Z Mechanism is retracted from the flow and the access door is closed. The air lock is then opened for probe work.

The survey probe height relative to the model was monitored using a high-magnification closed-circuit television (CCTV) system. The camera for this system was fitted with a telescopic lens system which gives a magnification factor of 20 for the monitor image. The probe and model were back-lighted using the collimated light beam of the Tunnel B shadowgraph system which produced a high-contrast silhouette of the model-probe outline. The camera was mounted on a horizontal-vertical traversing mount to facilitate alignment of the camera with the probe at various model stations visible through the test section windows. The video camera was interfaced with an image analyzer/digitizer system (IADS) which was used to measure the distance between the probe and model surface using computer-assisted image analysis techniques. The software for making these measurements was designed to locate the lower edge of the probe and the upper edge of the model surface automatically, thus minimizing inconsistencies associated with location of the edges by an operator using a cursor. The measurement accuracy was further improved by calibrating the system prior to testing, using the automated edge-location technique to locate edges separated by a known distance.

A hardcopy of the video image of the probes and model edge was provided in near real-time showing, by means of a graphics line, the location of the edges measured and displaying a printout of the measured distance and other pertinent documentation (Fig. 6). The accuracy of this measurement technique was determined to be better than ±0.0007-in. over a range of 0.003 to 0.2 in. under air-off conditions. Provisions were made to determine the magnitude of edge movement caused by probe and model vibrations and to calculate a correction factor for the measurements if required. However, vibrations of the model and probes were negligible when measurements were made under the present test conditions.

The model was oriented in roll to avoid interference of the surface instrumentation with the boundary-layer probes. The flow-field surveys were obtained only after the model had reached equilibrium temperature. Initial probe positioning near the model surface prior to each survey was accomplished by manual maneuvers of the probe controller while observing the CCTV monitor. The docking and surveys were accomplished by the following procedures.

After model injection, the probe mechanism was positioned by the controller (in manual mode) to the count reading which corresponded to the desired survey station location (X-position); the X-drive was locked into this position and held constant during the survey. The probe mechanism was then slowly driven downward in the direction normal to the surface until the lowest mounted probe was just above the model surface as viewed by the CCTV monitor. At this time, measurements were made using the IADS and were entered into the data reduction program as manual inputs. The flow field was then traversed in selected increments to acquire the desired data. At the completion of the traverse, the X-drive was unlocked and repositioned at the next survey station on the model.

3.2 DATA ACQUISITION

The primary test technique used in the present investigation of the initial development of instabilities in a laminar boundary layer was hot-wire anemometry. In addition, mean-flow boundary-layer profile data (pitot pressure and total temperature) were acquired in order to define the flow environment in the vicinity of the hot-wire. Surface pressure and temperature distributions on the model were obtained to supplement the profile data. Model surface heat-transfer data were acquired to assess effects of model angle of attack on the location of boundary-layer transition. The various types of data acquired are summarized in Table 3. Model stations for mean-flow surveys are listed in Table 4.

3.2.1 Hot-Wire Anemometry Data

The hot-wire anemometer data acquired during the present testing were of two general categories: (1) continuous-traverse surveys of the boundary layer to map the response of the hot-wire anemometer as a function of distance normal to the surface and (2) quantitative hot-wire measurements using the wire operated at each of a series of wire heating currents at one location on each profile. The anemometer probes used are identified in Table 3g.

Data of the first category were acquired with the hot wire operated using a single heating current, in the present case the maximum (practical) current. The probe was generally translated in a continuous manner from near the model surface outward to a distance of approximately 2 (DEL). These data were recorded as analog plots of the hot-wire response (rms of the a-c voltage component) versus probe height normal to the model surface. The plot was used primarily for the purpose of determining the station in the boundary-layer profile where the hot-wire output had a maximum level.

Quantitative hot-wire data (second category) were acquired at locations determined from the continuous-traverse surveys (first category data). The point of maximum rms voltage output of the hot wire, the "maximum energy point" of the profile, was selected for quantitative measurements at each model station. The quantitative data were acquired using each of a sequence of two or more wire heating currents; one current was nominal-zero to obtain a measurement of the electronic noise of the anemometer instrumentation. Each wire heating current, wire mean voltage (d-c component) and the rms value of the wire voltage fluctuation (a-c component) were measured 40 times, using the Tunnel B data system, at the same time the parameters were being recorded (generally, a five-second record duration) on magnetic tape with a tape transport speed of 120 in./sec.

3.2.2 Flow-Field Survey Data

Mean-flow boundary-layer profiles extended from a height of 0.02 in. above the model surface to somewhat beyond the edge of the boundary layer. A profile typically consisted of 25 to 40 data points (heights). The probe direction of travel was normal to the surface.

3.2.3 Model Surface Data

Surface pressure and temperature distributions on the model were obtained to supplement the boundary-layer profile data. For surface heat-transfer data, the model was injected into the tunnel test section at a fixed attitude. The data were recorded continuously for a period of approximately five seconds beginning one second after the model encountered tunnel centerline. The model was then retracted into the test section tank and cooled with high pressure air.

3.2.4 Anemometer and Total Temperature Probe Calibrations

The evaluation of flow fluctuation quantitative measurements made using hot-wire anemometry techniques requires a knowledge of certain thermal and physical characteristics of the wire sensor employed. In application of the hot wire to wind tunnel tests, two complementary calibrations are used to evaluate the wire characteristics needed. The first calibration of each hot-wire probe is performed in the instrumentation laboratory prior to the testing: the probe is placed in an oven, and the resistance of the wire is determined as a function of applied wire heating current at several oven temperatures between room temperature and 600°F. The wire reference resistance at 32°F and the thermal coefficient of resistance, also at 32°F, are obtained from the results; the wire aspect (length-to-diameter) ratio is determined, using the wire resistance per unit length specified by the manufacturer with each supply of wire. Moreover, it has been established that the exposure of the probes to the elevated temperatures of the oven calibration often serves to eliminate probes with inherent weaknesses.

Each hot-wire probe used for flow-field measurements is calibrated in the wind tunnel free-stream flow to obtain both the heat-loss coefficient (Nusselt number) and the temperature recovery factor characteristics of the wire sensor as functions of local Reynolds number. The variations of Reynolds number in the free stream are obtained by varying the tunnel total pressure (PT) while holding the tunnel total temperature (TT) at a nominally constant level. The resulting relationships are used to determine the values of the various wire sensitivity parameters required in the reduction of the quantitative measurements.

A calibration of the recovery factor of the total-temperature probe as a function of local Reynolds number was made in the free-stream flow of the tunnel test section simultaneously with the calibration of the hot-wire probes. The local total temperature for the probes in free-stream flow was assumed to be equal to the measured stilling chamber temperature, TT (see Section 3.3.4).

3.3 DATA REDUCTION

3.3.1 Hot-Wire Anemometry (Data Types 6 and 9)

In the present discussion, as it pertains to the reduction of hot-wire anemometer data, only the basic measurements tabulated in the data package that accompanies this report will be considered. (Examples of these tabulations are shown in Appendix III.) The data processing associated with spectral analysis, modal analysis, and determination of amplification rates of laminar disturbances is beyond the scope of this report. Extended data reduction of the hot-wire results to achieve these analyses is planned for the present measurements.

The basic measurements associated with quantitative hot-wire data are the following parameters: wire heating current, wire mean voltage, and the rms value of the wire fluctuating response voltage. The average value of 40 measurements of each of these three parameters was determined over a period of 5 sec for each nominal wire heating current employed, and the results were tabulated under the designation "DATA TYPE 9" together with certain associated model, flow field, and tunnel conditions. (See Sample 1, Appendix III.)

Free-stream tunnel conditions that are applicable to anemometer and total-temperature probe calibrations are tabulated under the designation "DATA TYPE 6". (See Sample 2, Appendix III.)

3.3.2 Mean Flow-Field Surveys (Data Type 4)

The mean flow-field data reduction included calculation of the local Mach number and other local flow parameters, determination of the height of each probe relative to the model surface, correction of the total-temperature probe using an appropriate recovery factor, definition of the boundary-layer total thickness, and evaluation of the

displacement and momentum thicknesses. Sample tabulated data are shown in Sample 3, Appendix III, and typical plotted results are shown in Fig. 7. The data reduction procedures are outlined as follows.

The local Mach number in the flow field around the model was determined using the measured pitot pressure (PP) and the local model static pressure (PWL) with the Rayleigh pitot formula.

The height of each probe above the model surface, in the normal direction, was calculated for each point in a given flow-field survey, taking into consideration the following parameters: the initial vertical distance determined from the CCTV image, the distance traversed in the vertical direction from the initial position employing the survey probe drive, the lateral displacement of the probe from the vertical plane of symmetry of the model, and the local radius of the model at the survey station.

The height of the pitot pressure probe above the model surface (ZP) was used as the reference for all probes because the pitot probe was located in the vertical plane of symmetry of the model. The total-temperature probe recovery temperature measurements (TTTU) were used to interpolate (three-point) a value (TTLU) corresponding to each height of the pitot probe. Correction of the interpolated recovery temperature, using the probe calibration data, was achieved by iteration on the local Reynolds number beginning with the value calculated using the recovery temperature (TTLU) to determine an initial value for the local dynamic viscosity (MUTTL). The iteration was continued until successive values of the "corrected" total temperature differed by no more than 0.1 deg R. For those surveys wherein the pitot probe was positioned below the total-temperature probe (closer to the model surface), the corrected total temperature at the corresponding pitot probe heights was determined from a second-order curve fit using three points, namely: the model surface temperature (TWL) and the corrected total temperature at the first two probe heights, where it was available.

The total thickness of the model boundary layer in any given profile was inferred from the profile of the total-temperature probe recovery temperature (TTLU). Recovery temperatures measured above the edge of the boundary layer (in the shock layer) remained constant or essentially independent of the probe height. There was generally a very distinct "overshoot" in the recovery temperature profile immediately before the onset of the constant portion of the profile. The height at which this constant portion of the profile began was defined as the edge of the boundary layer and the corresponding distance normal to the model surface was defined as the boundary-layer total thickness (DEL). Displacement and momentum thicknesses were determined by integration accounting for the model cone angle and local radius of curvature. Probe/model interference was noted for some of the data points near the model surface; these points were omitted from the integrations.

Model surface pressure and temperature distributions were measured during mean flow-field surveys, "DATA TYPE 4" (Sample 3, Appendix III). These measurements were made each time that probe data were acquired and the 25 to 40 values for each pressure or temperature were averaged. The averaged values and their respective standard deviations are included in the tabulations of DATA TYPE 4.

3.3.3 Model Surface Measurements (Data Type 2)

Model surface pressure and temperature distributions generally were obtained when the survey probe mechanism was located so as not to interfere with the measurements. These data are tabulated under the designation "DATA TYPE 2". (See Appendix III, Sample 4.)

The local model surface pressure, PWL, used in the boundary-layer calculations was determined using a fairing of the measured pressure distributions (selected runs of DATA TYPE 2). The static pressure was assumed to be constant across the boundary layer and shock layer and equal to the local model surface pressure at each survey station. The fairing of the surface pressure distribution used for each test condition is shown in Fig. 8.

The local model surface temperature, TWL, was determined for each survey from the measured surface temperature data in the vicinity of the survey station, using linear interpolation. A typical surface temperature distribution is shown in Fig. 9.

3.3.4 Total-Temperature Probe Calibration (Data Type 6)

The recovery factor ETA used in reducing the total-temperature probe survey data is defined generally as a function of the local Reynolds number based on probe diameter. In the case of the probe used in the present test, the factor ETA was essentially independent of Reynolds number; that is, ETA = constant for the test conditions being considered.

Free-stream tunnel conditions that are applicable to the total-temperature probe calibration are tabulated under the designation "DATA TYPE 6" (Appendix III, Sample 2).

3.3.5 Surface Heat-Transfer Data

The basic heat-transfer measurement is the wall temperature (TW). The heat-flux rate, calculated from the response of the coaxial thermocouple gage, is used to determine the heat-transfer coefficient, HT(TT), and the Stanton number, ST(TT). These values are tabulated under the designation "SURFACE HEAT TRANSFER". A sample tabulation is given in Appendix III, Sample 5.

3.4 UNCERTAINTY OF MEASUREMENTS

In general, instrumentation calibrations and data uncertainty estimates were made using methods recognized by the National Bureau of Standards (NBS), (Ref. 9). Measurement uncertainty (U) is a combination of bias and precision errors defined as:

$$U = \pm(B + t_{95}S)$$

where B is the bias limit, S is the sample standard deviation, and t_{95} is the 95th percentile point for the two-tailed Students "t" distribution, which equals approximately 2 for degrees of freedom greater than 30.

Estimates of the measured data uncertainties for this test, including the basic hot-wire anemometer measurements discussed in this report, are given in Tables 2a and b. Estimates of uncertainties in flow fluctuations derived from the hot-wire anemometer measurements and in other calculated flow survey parameters fall outside the scope of this report. In general, measurement uncertainties are determined from in-place calibrations through the data recording system and data reduction program.

The propagation of the estimated bias and precision errors of the measured data through the data reduction was determined for free-stream parameters in accordance with Ref. 9, and is summarized in Table 2b.

4.0 DATA PACKAGE PRESENTATION

Boundary-layer profile data, model surface data, probe calibration data, and basic hot-wire anemometer data from the test were reduced to tabular and graphical form for presentation as a Data Package. Examples of the basic data tabulations are shown in Appendix III.

Figure 7 is an example of the plotted mean-flow boundary-layer survey results for the sharp cone configuration at a particular survey station which are included in the Data Package.

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1. Siler, L. G. and Donaldson, J. C. "Boundary-Layer Measurements on Slender Blunt Cones at Free-Stream Mach Number 8," AEDC-TSR-79-V71, December 1979.

2. Carver, D. B., Siler, L. G., and Donaldson, J. C. "Boundary-Layer Measurements on Slender Blunt cones at Mach Number 8 - Part II," AEDC-TSR-80-V36, July 1980.

3. Donaldson, J. C. and Hildebrandt, L. A. "Boundary-Layer Measurements on Slender Blunt Cones at Mach Number 8 - Part III," AEDC-TSR-81-V27, August 1981.

4. Donaldson, J. C., Simons, S. A., and Byers, M. J. "Boundary-Layer Stability Measurements on a Sharp Cone at Small Angles of Attack," AEDC-TSR-83-V42, November 1983.

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6. Trimmer, L. L. et al. "Measurements of Aerodynamic Heat Rates at the AEDC von Karman Facility." Reprint from ICIASF 1973 Record, International Congress on Instrumentation in Aerospace Simulation Facilities, September 1973.

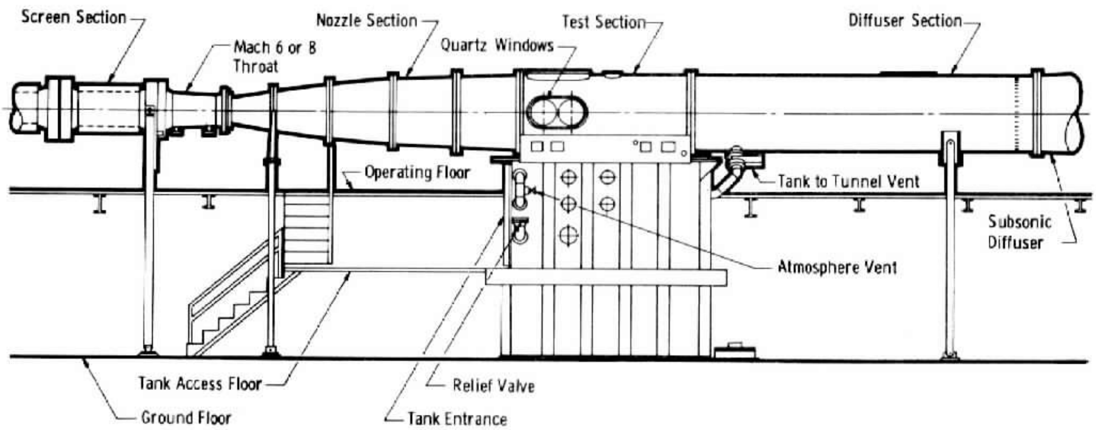
7. Cook, W. J. and Felderman, E. J. "Reduction of Data from Thin-Film Heat Transfer Gages: A Concise Numerical Technique," AIAA Journal Vol. 4, No. 3, March 1966, p. 561.

8. Donaldson, J. C., Nelson, C. G., and O'Hare, J. E. "The Development of Hot-Wire Anemometer Test Capabilities for $M_\infty = 6$ and $M_\infty = 8$ Applications," AEDC-TR-76-88 (AD A029570), September 1976.

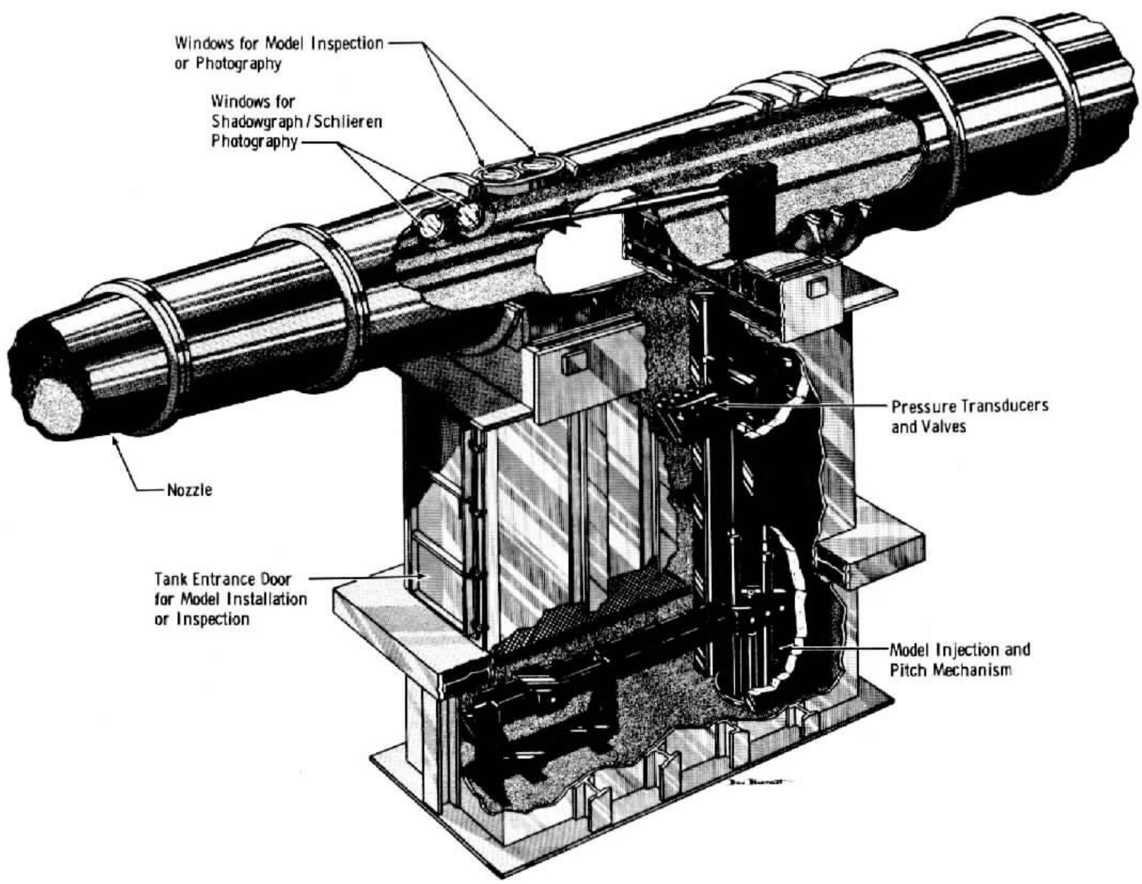
9. Abernethy, R. B. et al., and Thompson, J. W. "Handbook Uncertainty is Gas Turbine Measurements," AEDC-TR-73-5 (AD755356), February 1973.

APPENDIX I

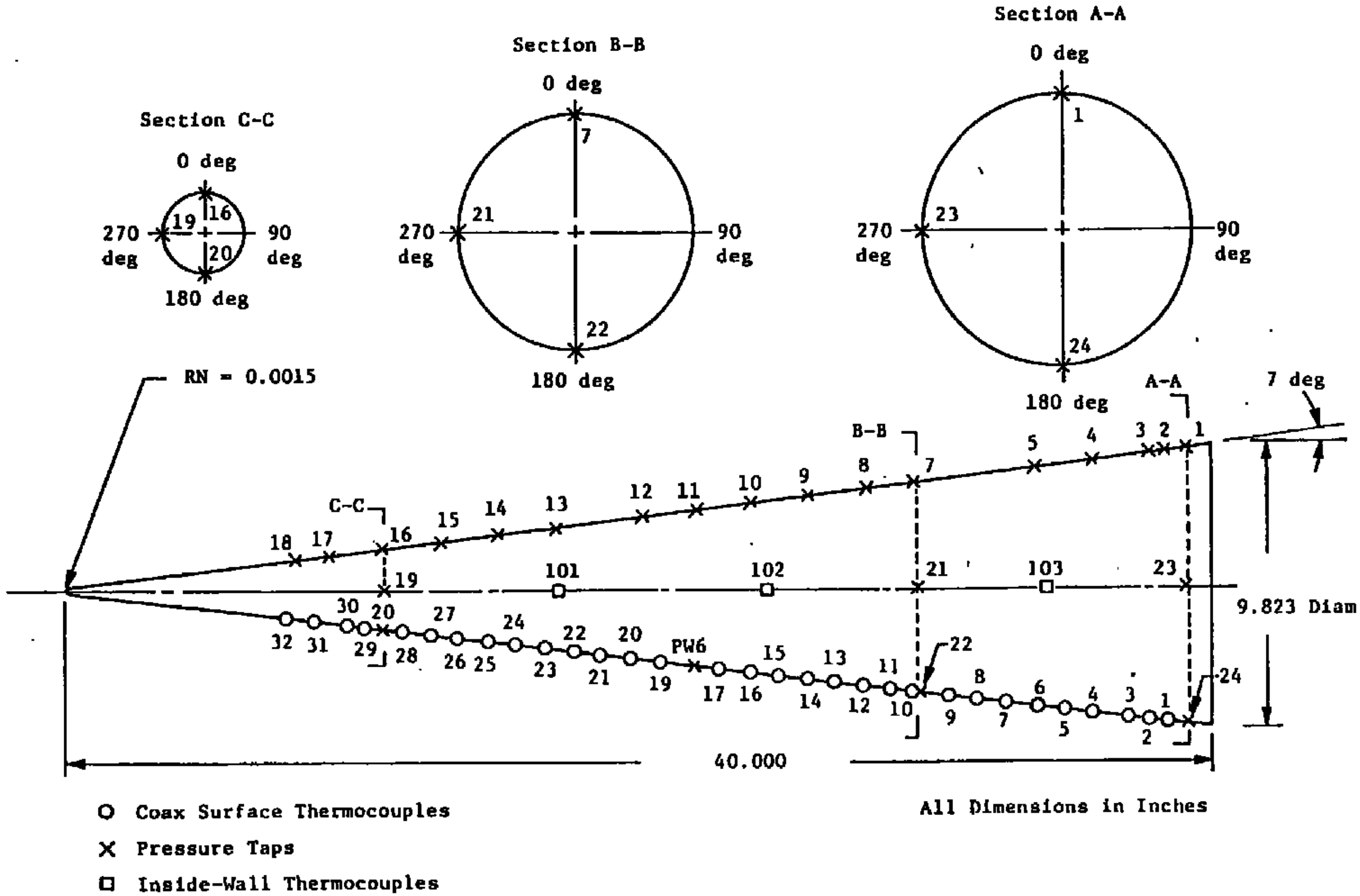
ILLUSTRATIONS



a. Tunnel assembly



b. Tunnel test section
Fig. 1. Tunnel B



Thermocouples and Pressure Taps

Figure 2. Model geometry and gage locations

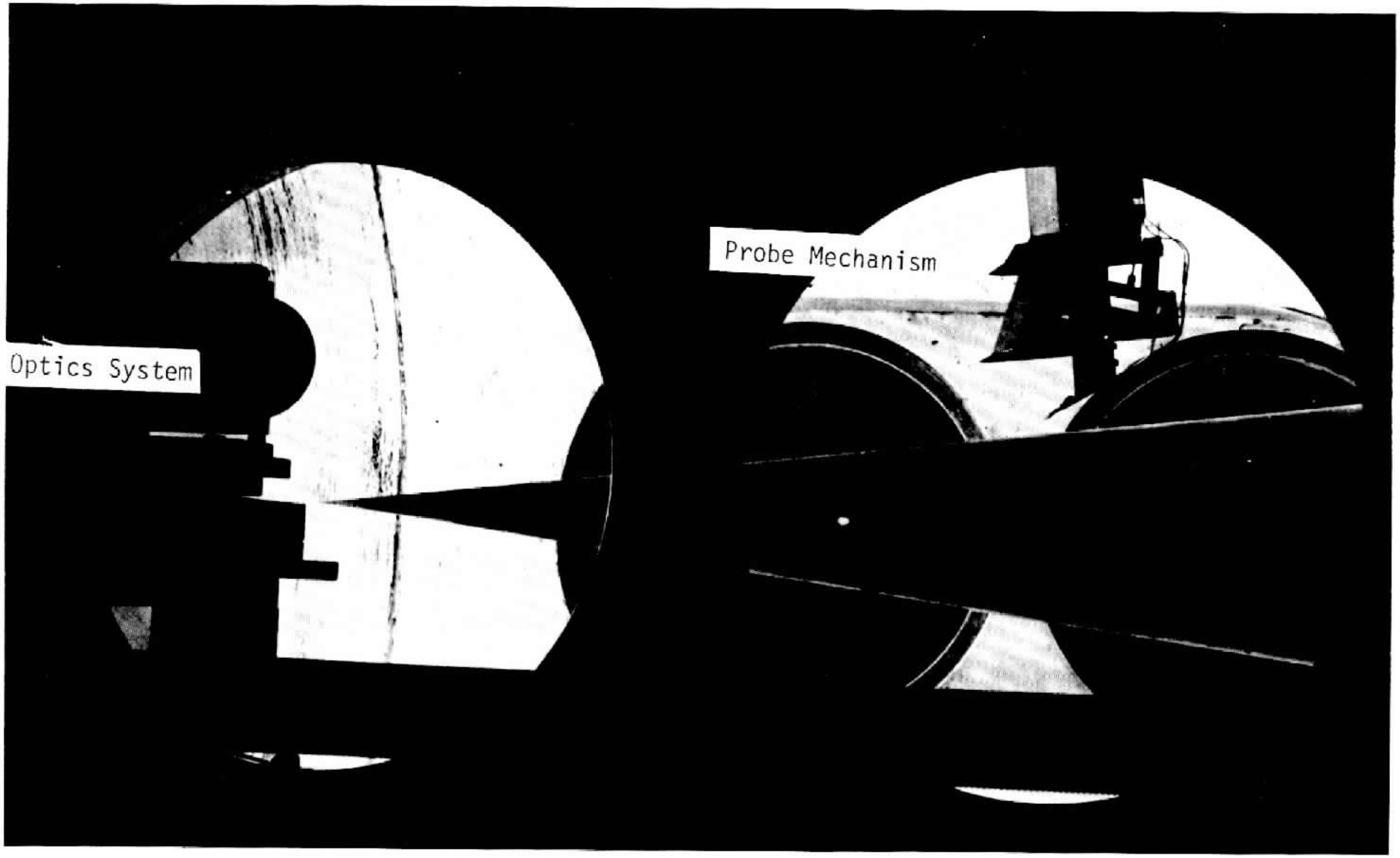
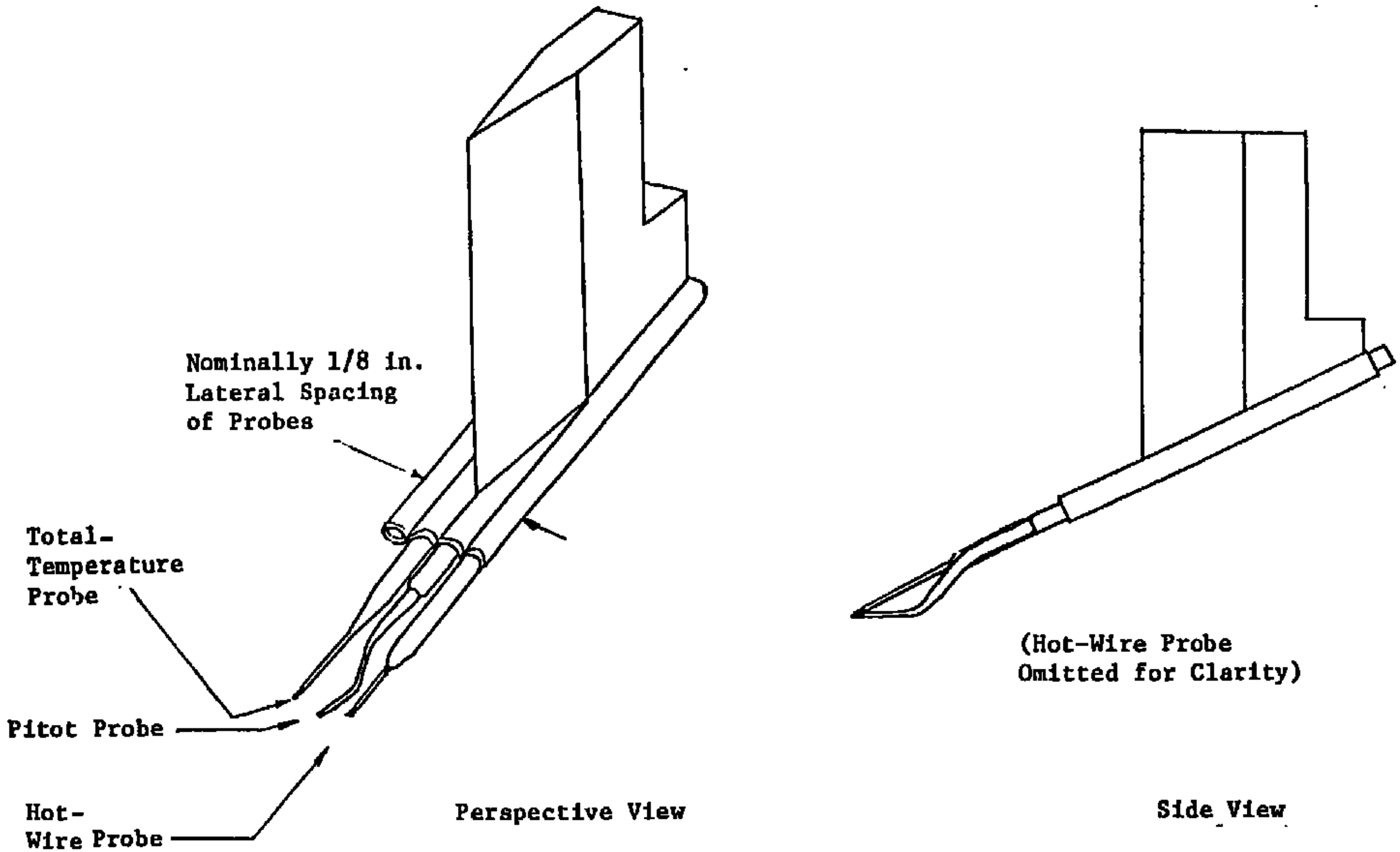
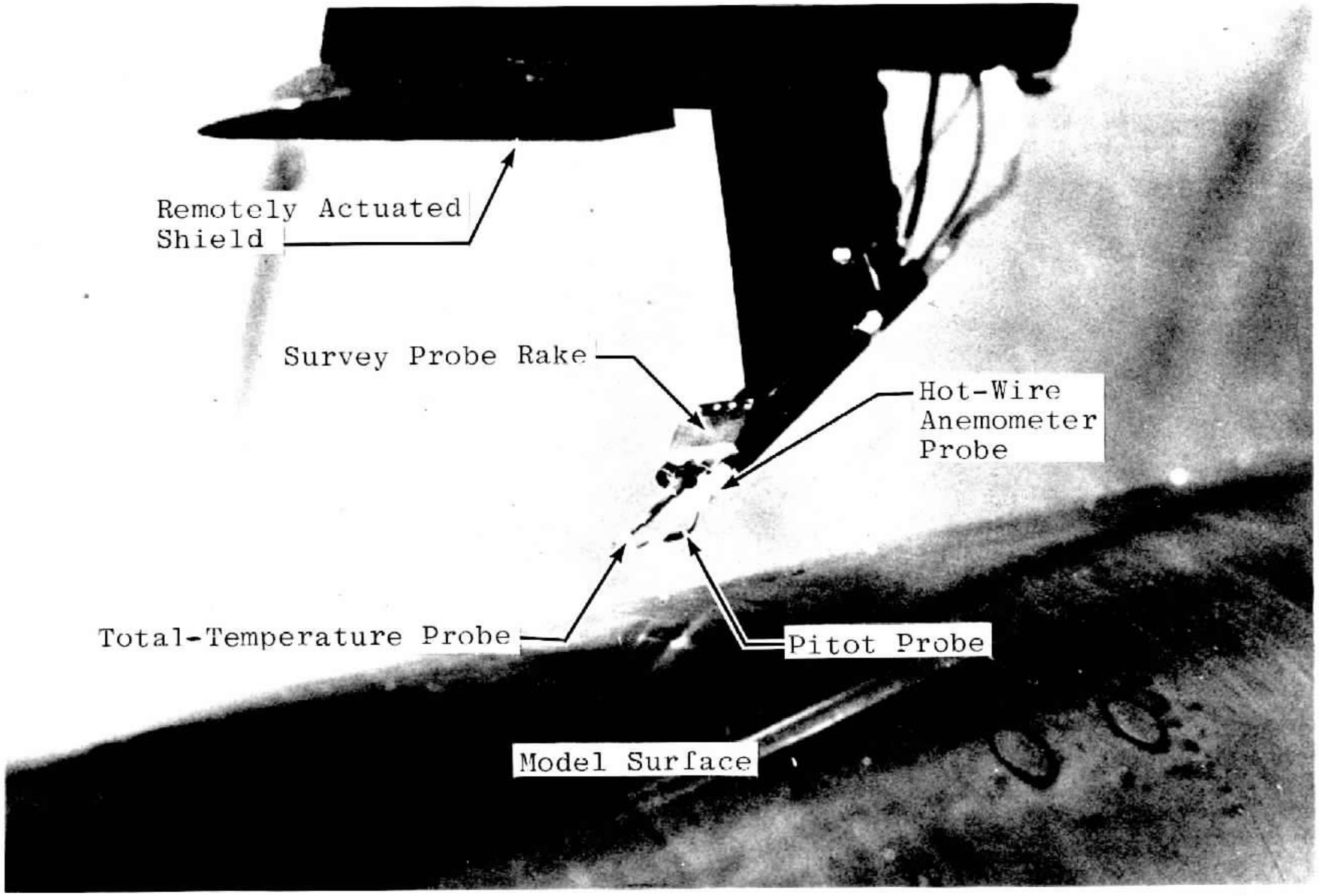


Figure 3. Test Installation



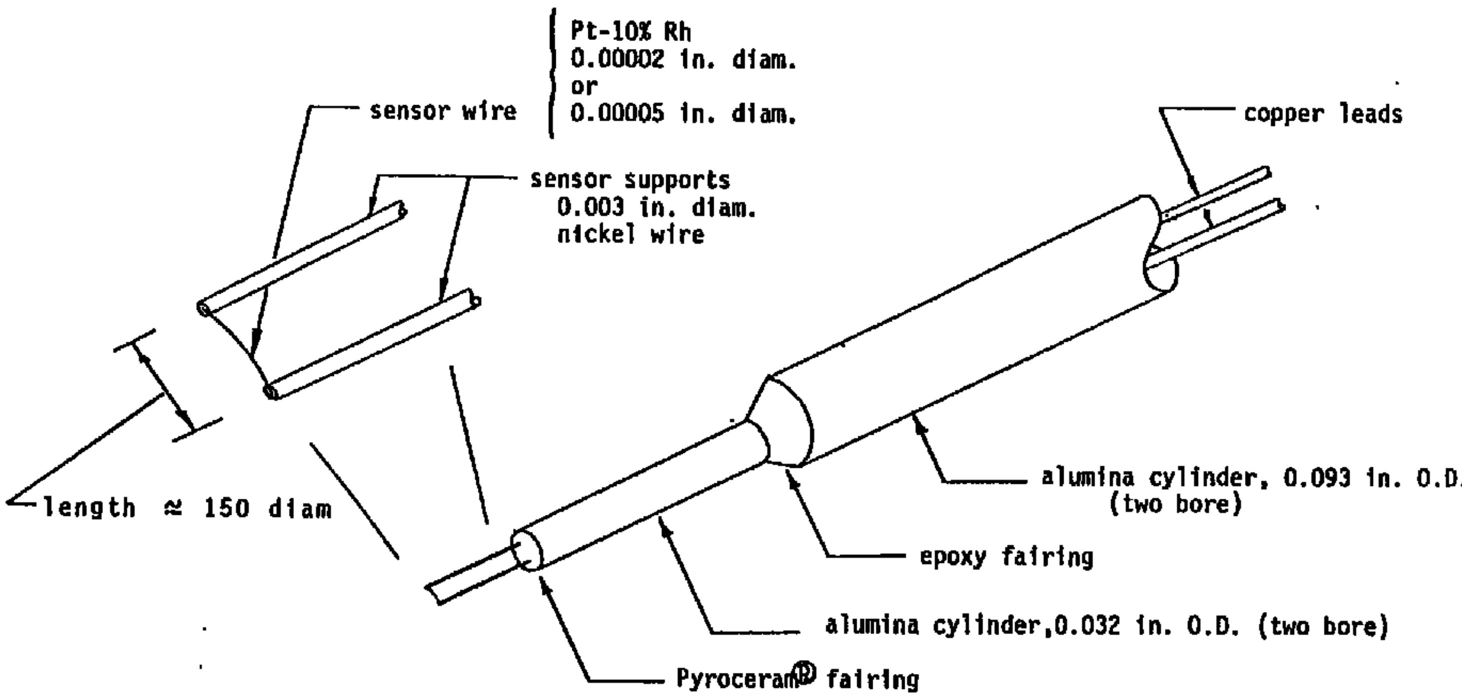
a. Rake and Probe Installation

Figure 4. Survey Probe Rake



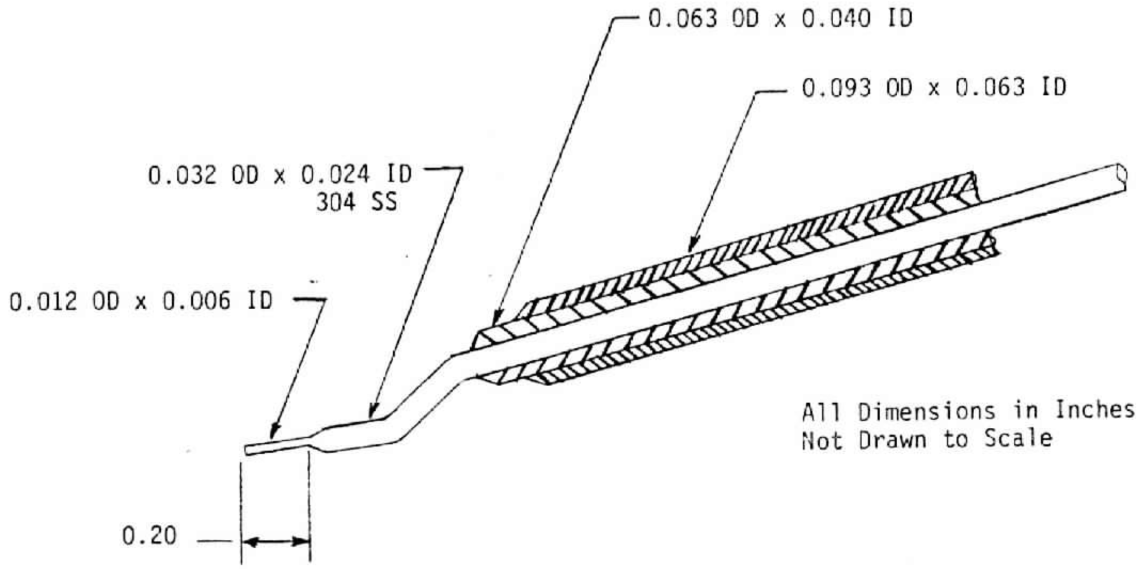
b. Rake/probe mounted above Model Surface

Figure 4. Concluded

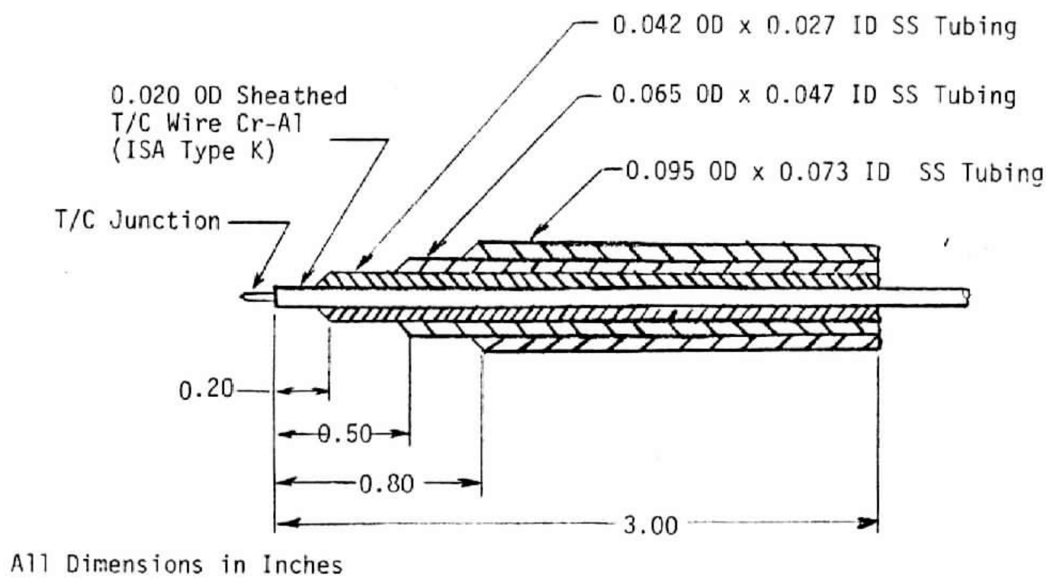


a. Hot-wire anemometer probe

Figure 5. Probe details



b. Pitot probe



c. Total-temperature probe

Figure 5. Concluded

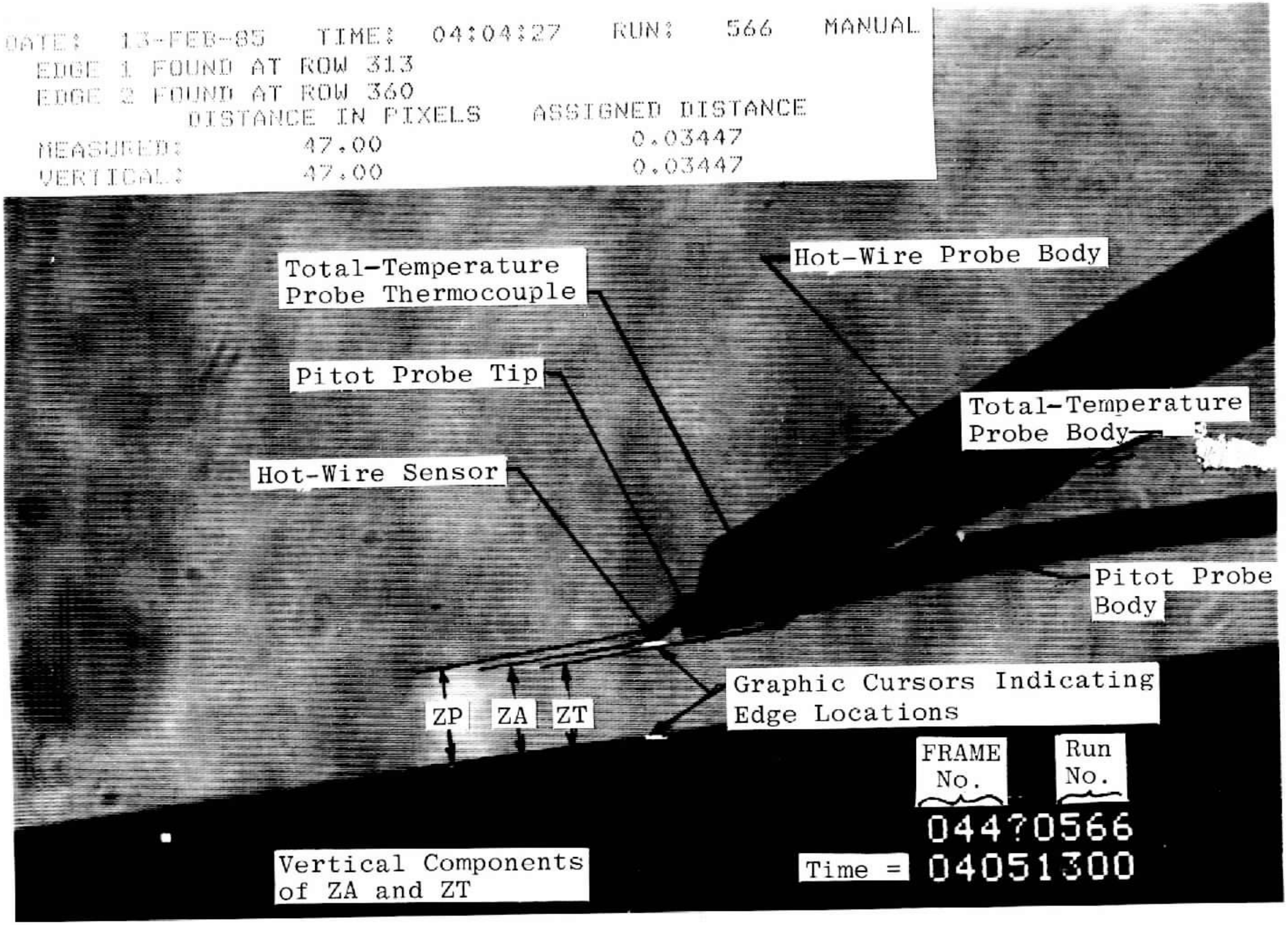


Figure 6. Video image of probe-model edge with measurement printout

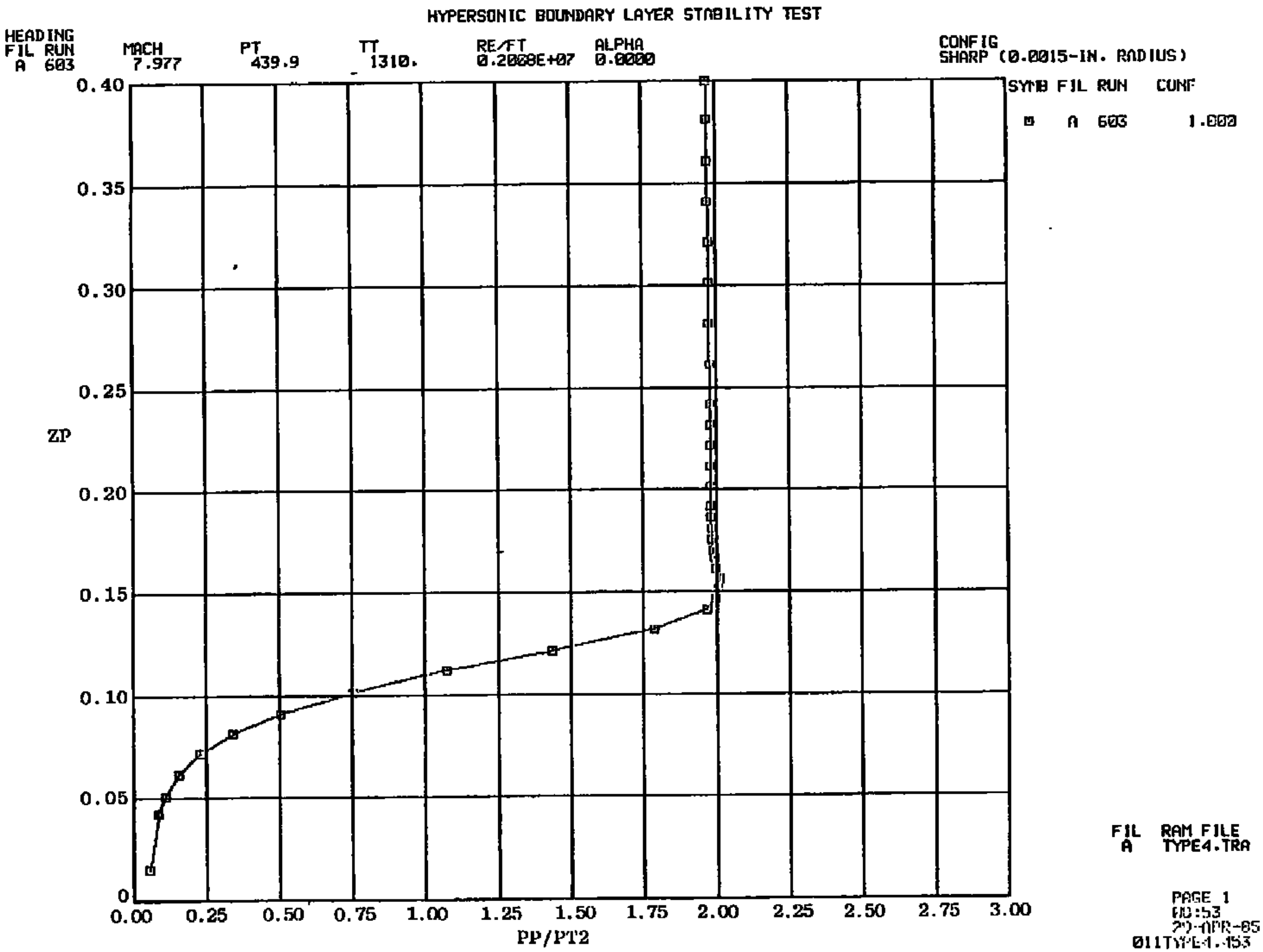


Figure 7. Sample results of a mean-flow boundary-layer survey

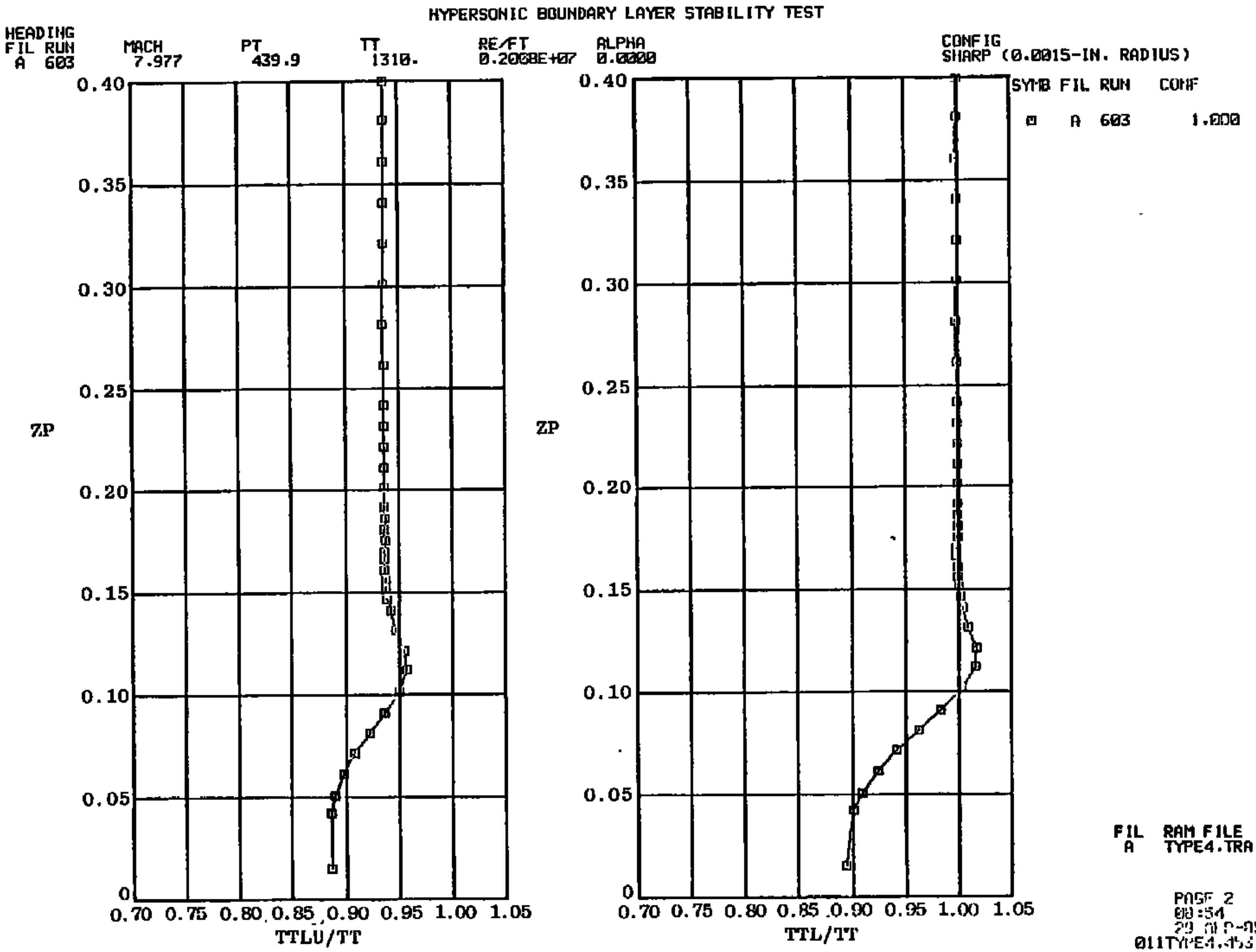


Figure 7. Continued

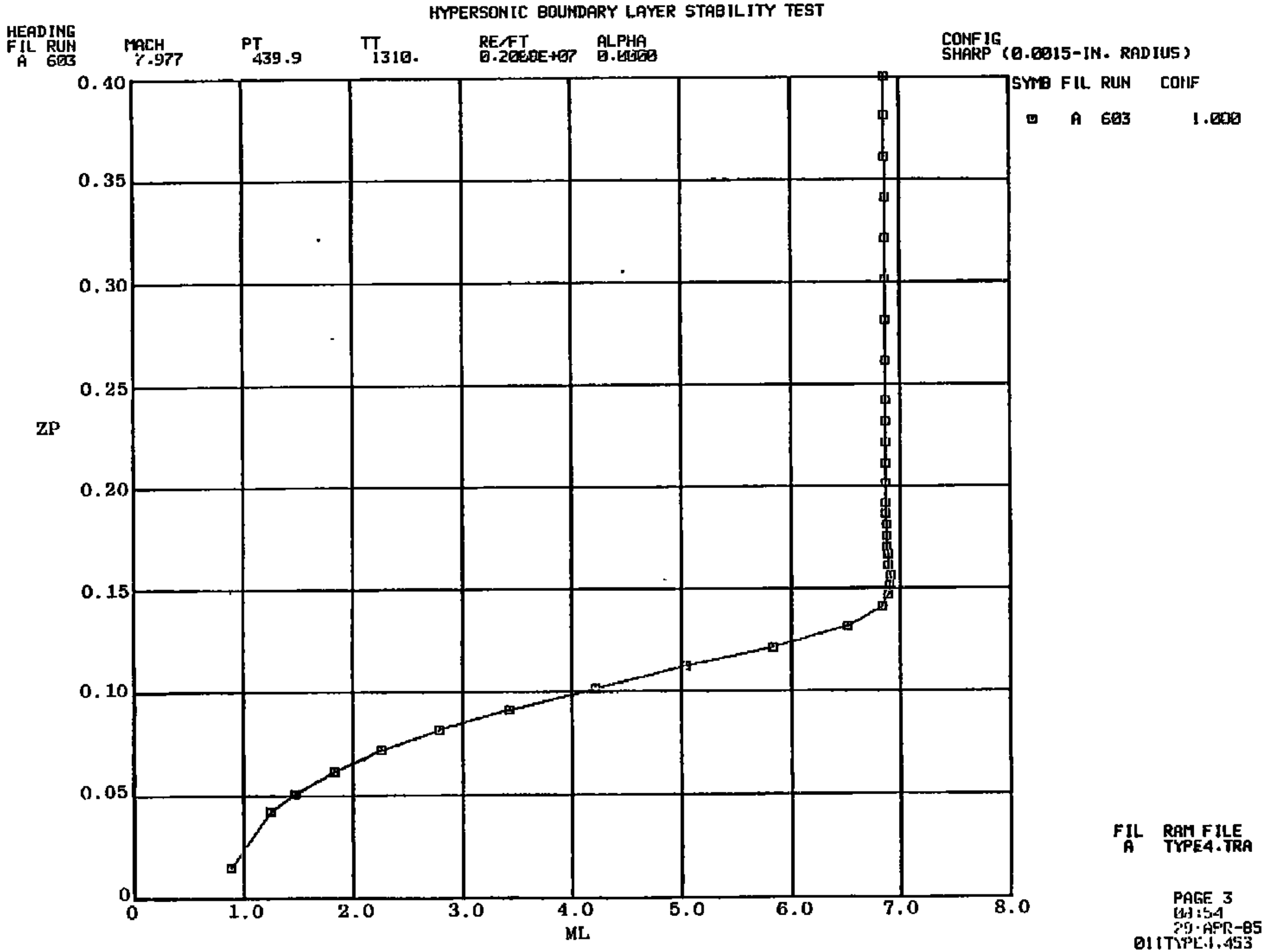


Figure 7. Concluded

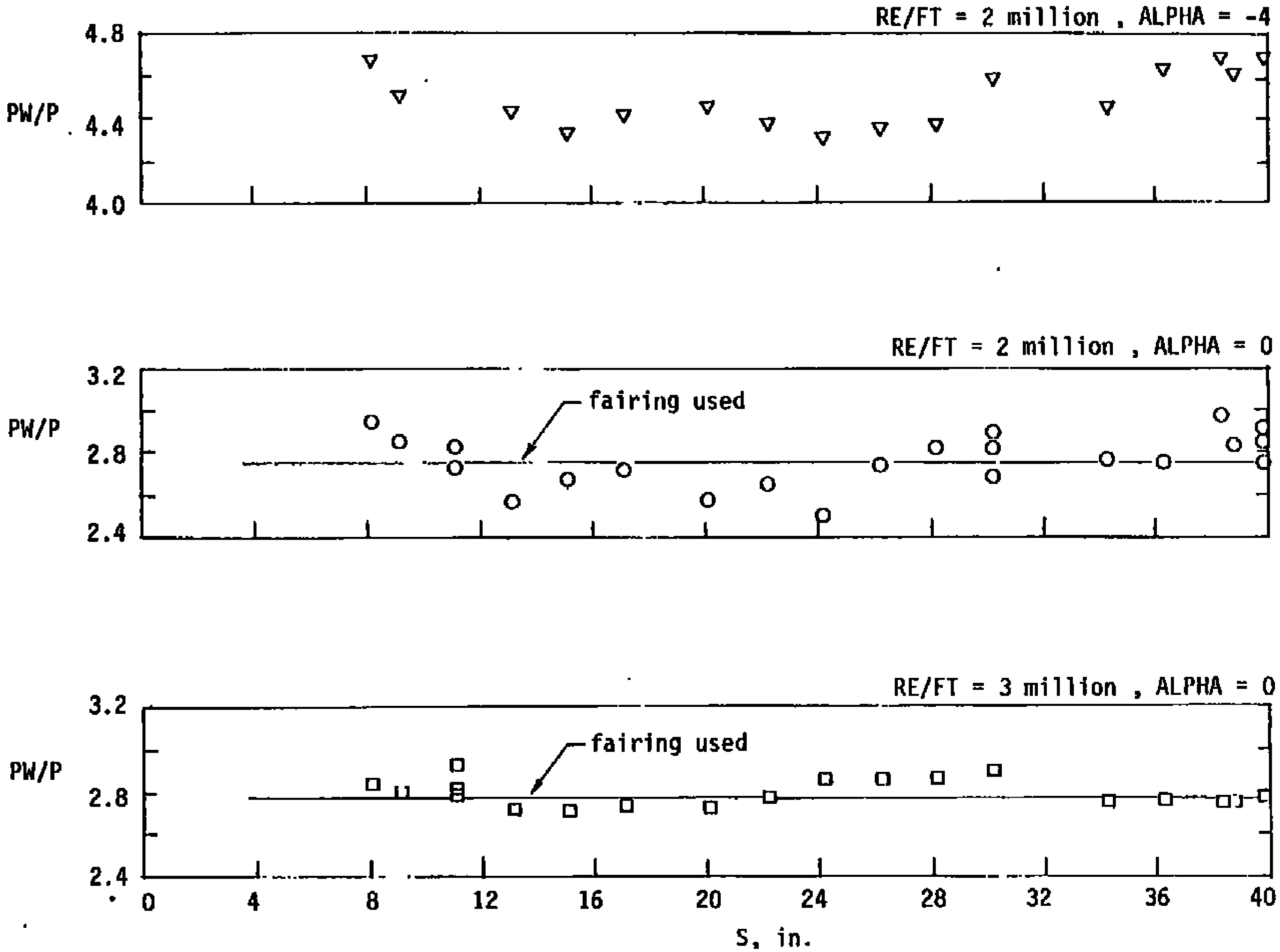


Figure 8. Surface pressure distributions

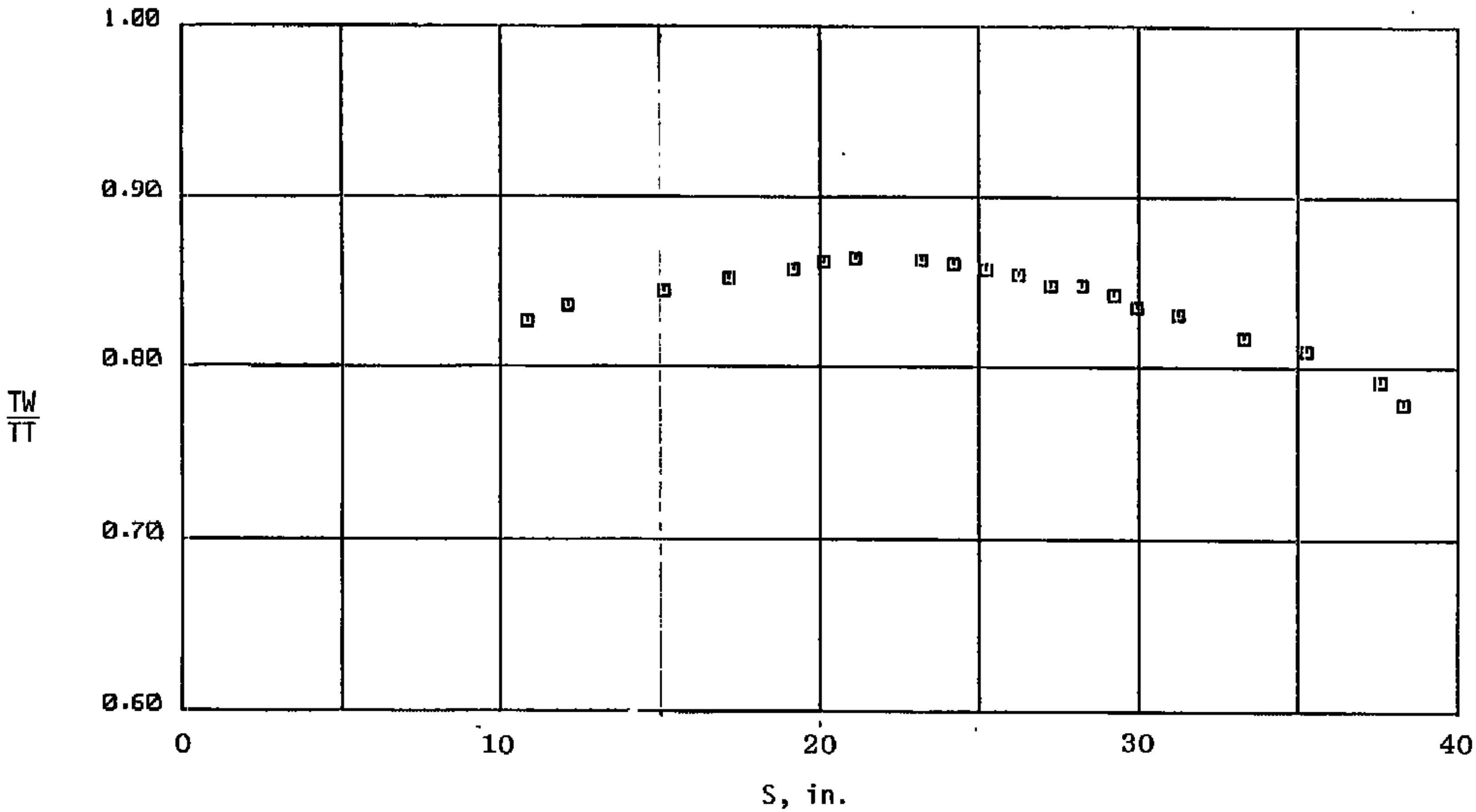


Figure 9. Typical Surface Temperature Distribution, RE/FT = 3.0 million

APPENDIX II

TABLES

TABLE 1. Model Instrumentation Locations

a. Pressure taps

TAP NO.	THETA deg	X, in.	S, in. RN=0.0015	0.15	0.25	0.50	0.70	0.90	2.00
1	0	39.50	39.790	38.796	38.126	36.452	35.113	33.774	26.409
2	↓	38.51	38.790	37.796	37.126	35.452	34.113	32.774	25.409
3	↓	38.01	38.290	37.296	36.626	34.952	33.613	32.274	24.909
4	↓	36.03	36.290	35.296	34.626	32.952	31.613	30.274	22.909
5	↓	34.04	34.290	33.296	32.626	30.952	29.613	28.274	20.909
7	↓	30.01	30.230	29.236	28.566	26.892	25.553	24.214	16.849
8	↓	28.03	28.230	27.236	26.566	24.892	23.553	22.214	14.849
9	↓	26.05	26.230	25.236	24.566	22.892	21.553	20.214	12.849
10	↓	24.06	24.230	23.236	22.566	20.892	19.553	18.214	10.849
11	↓	22.07	22.230	21.236	20.566	18.892	17.553	16.214	8.849
12	↓	20.00	20.140	19.146	18.476	16.802	15.463	14.124	
13	↓	17.02	17.140	16.146	15.476	13.802	12.463	11.124	
14	↓	15.04	15.140	14.146	13.476	11.802	10.463	9.124	
15	↓	13.05	13.140	12.146	11.476	9.802	8.463	7.124	
16	↓	11.07	11.140	10.146	9.746	7.802	6.463	5.124	
17	↓	9.08	9.140	8.146	7.476	5.802	4.463	3.124	
18	↓	8.09	8.140	7.146	6.476	4.802	3.463	2.124	
19	270	11.07	11.140	10.146	9.476	7.802	6.463	5.124	
20	180	11.07	11.140	10.146	9.476	7.802	6.463	5.124	
21	270	30.01	30.230	29.236	28.566	26.892	25.553	24.214	16.850
22	180	30.01	30.230	29.236	28.566	26.892	25.553	24.214	16.850
23	270	39.50	39.790	38.796	38.126	36.452	35.113	33.774	26.410
24	180	39.50	39.790	38.796	38.126	36.452	35.113	33.774	26.410

Table 1. Concluded

b. Thermocouple locations

T/C No.	THETA, deg	X, in.	S, in.						
			RN= 0.0015	0.15	0.25	0.50	0.70	0.90	2.00
1	180	38.51	38.790	37.796	37.126	35.452	34.113	32.774	25.409
2		38.01	38.290	37.296	36.626	34.952	33.613	32.274	24.909
3		37.32	37.590	36.596	35.926	34.252	32.913	31.574	24.209
4		36.03	36.290	35.296	34.626	32.952	31.613	30.274	22.909
5		35.04	35.290	34.296	33.626	31.952	30.613	29.274	21.909
6		34.04	34.290	33.296	32.626	30.952	29.613	28.274	20.909
7		33.05	33.290	32.296	31.626	29.952	28.613	27.274	19.909
8		32.00	32.230	31.236	30.566	28.892	27.553	26.214	18.849
9		31.01	31.230	30.236	29.566	27.892	26.553	25.214	17.849
10		29.72	29.930	28.936	28.266	26.592	25.253	23.914	16.549
11		29.02	29.230	28.236	27.566	25.892	24.553	23.214	15.849
13		27.04	27.230	26.236	25.566	23.892	22.553	21.214	13.849
15		25.05	25.230	24.236	23.566	21.892	20.553	19.214	11.849
17		23.07	23.230	22.236	21.566	19.892	18.553	17.214	9.849
19		20.99	21.140	20.146	19.476	17.802	16.463	15.124	2.932
20		20.00	20.140	19.146	18.476	16.802	15.463	14.124	0.977
21		19.01	19.140	18.146	17.476	15.802	14.463	13.124	
22		18.02	18.140	17.146	16.476	14.802	13.463	12.124	
23		17.02	17.140	16.146	15.476	13.802	12.463	11.124	
24		16.03	16.140	15.146	14.476	12.802	11.463	10.124	
25		15.04	15.140	14.146	13.476	11.802	10.463	9.124	
26		14.05	14.140	13.146	12.476	10.802	9.463	8.124	
27		13.05	13.140	12.146	11.476	9.802	8.463	7.124	
28		12.06	12.140	11.146	10.476	8.802	7.463	6.124	
29		10.77	10.840	9.846	9.176	7.502	6.163	4.824	
30		10.08	10.140	9.146	8.476	6.802	5.463	4.124	
31		9.08	9.140	8.146	7.476	5.802	4.463	3.124	
32		8.09	8.140	7.146	6.476	4.802	3.463	2.124	
101	-	18.5	37.3	17.7	17.0	15.3	13.95	12.6	
102	-	25	25.2	24.2	23.6	21.9	20.55	19.2	11.8
103	-	35	35.3	34.3	33.6	32.0	30.65	29.3	21.9

NOTES: 1. Thermocouples 1-32 were coaxial surface thermocouples and thermocouples 101-103 were simply attached to inside of model surface (model wall thickness ≈0.25 in.).
2. Locations of thermocouples 101-103 are approximate.

TABLE 2. Estimated Uncertainties

a. Basic measurements

SHEET NO. 1 OF 2

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
STILLING CHAMBER PRESSURE (PT or PT_R), psia		±0.1 psia	>30		±0.1 psia		±0.3 psia	0 to 900 psia	Paroscientific Digiquartz Pressure Transducer	Digital data acquisition system	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory
TOTAL TEMPERATURE (TT), °F		± 1° F ± 1° F	>30 >30	±0.375	±2° F	±(0.375% + 2° F)	±4° F	32° to 530° F 530° to 2300°F	Chromel-Alumel Thermocouple	Digital Thermometer and Micro Processor Averaged for Primary (TT_P); Digital Thermometer for Redundant (TTR)	Thermocouples verification of NBS conforming/voltage substitution calibration
PITCH ANGLE (ALPI), degs		±0.025°	>30				±0.05°	±15°	Potentiometer	Digital data acquisition system/analog-to-digital converter	Heidenhain rotary encoder ROD700 Resolution: 0.0006°
ROLL ANGLE (PHII), degs		±0.15°	>30				±0.3°	±180°	Potentiometer		Overall accuracy: 0.001
PITOT PRESSURE (PP), psia		± 0.002 psia			±0.010 psia		± 0.014 psia	<10 psid	Druck ±15 psid strain gage transducers	Analog to digital converter/ digital data acquisition system	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory
TTTU, °F		± 1.0 ± 1.0	>30 >30	±0.375	±2° F	±(0.375% + 2°F)	±4° F	<530°F <2300°F	Unshielded Chromel-Alumel Thermocouple		Thermocouple verification of NBS conformic voltage substitution calibration

TABLE 2. Estimated Uncertainties

a. Continued

SHEET NO. 2 OF 2

Parameter Designation	ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty ±(B + $t_{95}S$) Percent of Reading	Uncertainty ±(B + $t_{95}S$) Unit of Measurement	Range	Type of Measuring Device	Type of Recording Device	Method of System Calibration
MODEL PRESSURE (PM), psia		±0.00075 psi	>30	±1.0		±(0.0015 psi + 1.0%)		0 ≤ P ≤ 0.15 psid	Druck ±1psid strain gage transducers	Analog to digital converter/ digital data acquisition system	In-place application of multiple pressure levels measured with a pressure measuring device calibrated in the standards laboratory
		±0.002 psi	>30	±0.1		±(0.004 psi + 0.1%)		0.15 ≤ P ≤ 1.5 psid			
		±0.003	>30		± 0.002		± 0.007	<2.5	ESP® 2.5 psid strain gage transducer		
MODEL TEMPERATURE (TW), °F		±1° F	>30		±2.2°F		±4.2° F	<600	Chromel Constantan coaxial Thermocouple	Digital Data Acquisition System Analog-to-Digital Converter	Thermocouple verification of NBS conformic voltage substitution calibration
		±1° F	>30	±0.376		±0.380		<1600			
ZP, ZT, ZA, in.		±0.001	>30		±0.003		±0.005	<0.5	Potentiometer and Optical	Digital Data Acquisition System Analog-to-Digital Converter	Precision Micrometer
(SURVEY STATION), in.		± 0.005	>30		±0.020		±0.030	<35	Potentiometer and Optical Gradicule	Digital Data Acquisition System A/D Converter Optically Positioned Zero	Precision Micrometer
ERMS, mv CURRENT, ma EBAR, mv	± 0.5 ± 0.5 ± 0.5				0+ 0+ 0+	±1 ±1 ±1		<1200 <5 <300	Philco Ford Corp. Model #ADP-12/13 Hot-wire Anemometer System	Digital DAta Acquisition System Analog-to-Digital Converter	Precision Digital Voltmeter

NOTE: + -Bias assumed to be zero.

TABLE 2. Continued

a. Concluded

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	Range++ AMPLITUDE	Range++ FREQUENCY	Type of Measuring Device	Type of Recording Device	Method of System Calibration
Flow Turbulence	Unknown		--	Unknown		Unknown		DC to 1 volt RMS (Heating Currents up to 3 ma)	DC to 250 KHZ or 500 KHZ (freq. response band determined by filters used.	Hot Wire Anemometer System (20 microinch wire)	• Analog data recorded on tape for subsequent playback and reduction • 40 loops of data recorded on digital data acquisition system (AD converter) for each run	Wire characteristics by oven calibration Heat transfer characteristics by calibration in tunnel free-stream

*Inci. ID of present measurements

TABLE 2. Concluded

b. Calculated parameters

Parameter Designation	STEADY-STATE ESTIMATED MEASUREMENT* Precision Index (S) Percent of Reading	Precision Index (S) Unit of Measurement	Precision Index (S) Degree of Freedom	Bias (B) Percent of Reading	Bias (B) Unit of Measurement	Uncertainty $\pm(B + t_{95}S)$ Percent of Reading	Uncertainty $\pm(B + t_{95}S)$ Unit of Measurement	RE/FT $\times 10^{-6}$
P,psia	1.23		>30	0.25		2.72		1.0
PT2,psia	0.86			0.25		1.96		
Q,psia	0.85			0.25		1.96		
T,°R	0.36			0.25		0.97		
V,ft/sec	0.04			0.12		0.20		
RHO,lbm/ft^3	0.88			0.35		2.12		
MU,$lbf\text{-}sec/ft^2$	0.36			0.25		0.97		
M	0.19++			0+		0.38		
RE,per ft	0.53			0.44		1.50		
P,psia	0.82		>30	0.25		1.89		2.0
PT2,psia	0.57			0.25		1.39		
Q,psia	0.57			0.25		1.39		
T,°R	0.25			0.24		0.74		
V,ft/sec	0.04			0.12		0.20		
RHO,lbm/ft^3	0.59			0.35		1.53		
MU,$lbf\text{-}sec/ft^2$	0.25			0.24		0.74		
M	0.13++			0+		0.26		
RE,per ft	0.36			0.44		1.16		
P,psia	0.82		>30	0.25		1.89		3.0
PT2,psia	0.57			0.25		1.39		
Q,psia	0.56			0.25		1.37		
T,°R	0.24			0.25		0.73		
V,ft/sec	0.04			0.12		0.20		
RHO,lbm/ft^3	0.59			0.35		1.53		
MU,$lbf\text{-}sec/ft^2$	0.25			0.24		0.74		
M	0.13++			0+		0.26		
RE.per ft	0.36			0.44		1.16		

NOTE: +Bias assumed to be zero.

++Determined from test section repeatability and uniformity during tunnel calibration.

TABLE 3. Test Summary

a. Surface heat-transfer runs

Model Config.	ALPHA,deg	PHI,deg	RN, in.	RE/FT $\times 10^{-6}$	RUNS
7-deg Cone	0	-90	0.0015	2.5	2
				1.2	4
				1.0	5
			0.150	2.5	1
			0.250	3.5	202
			0.500	3.5	3
			2.000	3.5	113,116,119
	0	0	0.0015	1.0	401,402
	+2				403
	+4				404
	-2				405
	-4				406
	+4				521
	+3				519
	+2				517
	+1				515
	0				513,522
	-1				514
	-2				516
	-3				518
	-4				520
	+4		0.0015	2.0	509,510
	+3				507
	+2				505
	+1				503
	0				501,511,547 548,549,550
	-1				502
	-2				504
	-3				506
	-4				508,512
	+4		0.0015	3.0	544
	+3				542
	+2				540
	+1				538
	0				536,545,546
	-1				537
	-2				539
	-3				541
	-4				543

NOTE: Run numbers <200 from Ref. 1; Run numbers <300 from Ref. 2; Run numbers <400 from Ref. 3; Run numbers <500 from Ref. 4; Run numbers >500 are present test data.

TABLE 3. Continued

b. Surface pressure and temperature (Type 2 Data)

MODEL CONFIG	ALPHA,deg	PHI,deg	RN, in.	RE/FT $\times 10^{-6}$	RUN
7-deg Cone	0	-90	0.0015	1.3	358
			0.150	2.5	72,73
			0.350	2.5	210,211
			0.700	2.5	302,303,305
					312,313,314
					315,317,322
					330,339,340,
					341,343,349
	0	-85	2.000	3.5	130,131
			0.0015	0.5	408,409,410
				2.6	411,412
				1.0	429
	-2			1.0	430
	+2			1.0	431
	+2			0.6	448,449
	0			0.6	450,451
	-2			0.6	452,453
	-4			1.0	471,472
	-2			2.3	477
	0	0	0.0015	2.0	524
		-110			525,526,529,531,
					532,553,554,564,
					565,577,578,604,
					605,606,607
	-4	20	0.0015		608,609
	-4	0			617,618
	+4	0			619,620
	0	-110	0.0015	3.0	579,580,581,582,
					583,584,591,592,
					595,596
		0	0.0015		586,587

NOTES: 1. Run numbers <200 from Ref. 1; Run numbers <300 from Ref. 2; Run numbers <400 from Ref. 3; Run numbers <500 from Ref. 4; Run numbers >500 are present test data.

2. Surface pressure measurements are also included on Boundary-Layer Survey Data (Type 4).

TABLE 3. Continued

c. Mean-flow boundary-layer survey matrix
(Type 4 Data)

RN, in.	RE/FT x10^-6	ALPHA, deg	X STATION (NOMINAL) 6	8	10	11	15	16	18	20	24	25	26	28	30	31	32	35	36	37
0.0015	0.5	0																		272
	1.0	0			112		111			110		109			108			107		286[a]
	1.0	+2				459[b]			458[b]										456[b] 457[b]	
	1.3	0												373	372		371		370	
	2.0		601				602				603									
	3.0		600																	
0.15	2.5				106	105				76 104		103			75 102			74 101		
0.25	2.5				255[e] 254							249			241 208[c] 207[c]			240 242[c]		
0.70	2.5												376			377				378
0.90	2.5											257[e] 256								
2.00	3.5							124 125				123						122		

NOTES: 1. PHI = -90 deg except where noted.
2. Run nos. < 200 from Ref. 1; Run nos. <300 from Ref. 2; Run nos. < 400 from Ref. 3; Run nos. < 500 from Ref. 4; Run nos. > 500 are present test data
3. Superscripts:
a - ALPHA = -2.0 deg, PHI = 0. deg, windward survey
b - PHI = -85 deg
c - Cold wall data; TWL ≈ 525-, 640-, 640-deg R. for Runs 207, 208, 242, respectively.
All other data obtained at hot wall conditions (TWL ≥ 860 deg R).
e - Extended survey of preceding RUN, all outside boundary layer.

4

TABLE 3. Continued

d. Hot-wire qualitative survey matrix (Type 3/Type 4 Data), runs

RN, in.	RE/FT $\times 10^{-6}$	ALPHA, deg.	X STATION (NOMINAL)																	
			10	14	15	17	19	20	25	26	27	28	30	31	32	33	34	35	36	37
0.0015	1.0	0	51	46		42		34			26		21			16	15	12	11	8
	1.3	0										373	372		371				370	
0.15	2.5	0	96	88		84		79	67		64		60			57				54
0.25	2.5	0	255[e] 254										208[c] 207[c]					240 242[c]		
0.50	3.5	0	140		141	142		139	138									134		
0.70	2.5	0								376				377						378
0.90	2.5	0							257[e] 256											
2.00	3.5	0																129 132		

NOTES:
1. RUN numbers < 200 from Ref. 1; RUN numbers < 300 from Ref. 2; RUN numbers < 400 from Ref. 3.
2. RUN numbers < 200 obtained as Data Type 3; RUN numbers > 200 obtained as Data Type 4.
3. Superscripts:
   - c-- Cold Wall data, TWL ≈ 525-, 640-, 540-deg R. for RUNS 207, 208, 242, respectively. All others at hot wall conditions (TWL ≥ 860 deg R).
   - e - Extended survey of preceding run, all outside boundary layer.

TABLE 3. Continued

e. PART-I. Hot-wire quantitative run matrix (Type 9 Data) for ALPHA = 0, runs

R, in.	RE/FT x10^-6	ALPHA, deg	X STATION 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	41	42	FREE-STREAM RUN	X/2P
0.0015	0.5	0								269*		268*		267*		266*		265*		264*		263*		262*		261*		260*		259*		258*	273*	271*					270	13/4.9
	1.0	0					50	49	48	47	45	44	43	41	36 455*	35	33	32	31	30	29	28	27	25	26	23	20	19	18	17	16	13	10	9					38 39	9 3/4 9 3/2
	1.3	0																						339	340	341	342*	343*	365*	363*	364*	362*	361*	360*						
	2.0	0	563[a]	562[a]	561[a]	559[a]	558[a]	557[a]	556[a]	555[a]	566[a]	567[a]	568[a]	569[a]	570[a]	571[a]	572[a]	573[a]	574[a]	575[a]	576[a]																		551	-/?
	3.0	0	597[a]		590[a]	589	588[a]																																	
0.15	2.5	0					95	94	93	97 90	87	86	85	83	82	81	78	76	70	69	68	66	65	63	62	61	59	58		56		55		53					88,79 100	9.3/4 9.3/2
0.25	2.5	0															Note 3					233 251 250	236	235 239 232 244	234 233	225 224	223 222	221 220	219 238 247 218 239 246	217 216	215 214	213 232 212 231	230 229	228 245 227 244						
0.50	3.5	0																														135 136							117 118	14 3/4 14.3/2
0.70	2.5	0																		375	374	355	334	353	352	340 351	347	346	345	336 346 356	335	334	328 332 337	327 338 357	326	325 324	321 320	317 318		
2.00	3.5	0																														128 137								

NOTES:

1. Roll attitude: PHI = -90 deg for RUNS < 500; PHI = -110 deg for RUNS ≥ 500.
2. RUN numbers < 200 from Ref. 1, RUN numbers < 300 from Ref. 2; RUN numbers < 400 from Ref. 3; RUN numbers < 500 from Ref. 4.; and RUN numbers > 500 are present test data.
3. Two distinct maximum disturbance energy peaks were noted for some runs, "Outer Peak" RUN numbers listed above dashed line. "Inner Peak" RUN numbers listed below dashed line.
4. Superscripts:
   - a Single sensitivity for RUN numbers so noted. For all other RUNS data were obtained at 11 wire sensitivities.
   - * No "inner peak" observed, data obtained at approximate height where peak was previously observed.

e. PART-II. Hot-Wire Quantitative Run Matrix (Type 9 Data) for ALPHA ≠ 0, RUNS

R, in.	RE/FT x10^-6	ALPHA, deg	X STATION (NOMINAL) 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37				
0.0015	0.5	2.0		432	433		434 435		436		437		438		439		440		441		442		443		444		445	446	447					
	1.0	-2.0						427	426		425		424		423		422		285 421	284	283 420	282	281 419	280	279 418	278	277 417	276 416	275 415	274 414				
		-4.0										474	470		473		469	468		467		466		465		464		463	452 451	460				
	2.0	-4.0	612	613	611	614	610		615 616																									
0.70	2.5	-2.0																												475 476				

NOTES: 1. RUN numbers < 300 from Ref. 2; RUN numbers between 400 and 600 from Ref. 4; RUN numbers > 500 are present test data.
2. Single wire sensitivity for each RUN.

TABLE 3. Continued

f. Hot-wire anemometer and total-temperature probe calibration in free stream (Type 6 Data)

RUN	PT (range) psia	RE (range)x10^{-5}, per in.	Hot-Wire No.
6	202-355	0.75-1.3	6
7	150-352	0.56-1.3	7
37	152-352	0.57-1.3	7
52	352-579	1.3-2.1	8
77	349-577	1.3-2.1	14
80	300-582	1.1-2.1	15
92	300-577	1.1-2.1	17
114	400-804	1.4-2.9	3
126	399-808	1.4-2.9	2
133	398-806	1.4-2.9	1
137	399-807	1.4-2.9	16
209	200-580	0.74-2.1	31
226	201-579	0.76-2.1	33
243	199-579	0.74-2.1	40
301	214-581	0.80-2.1	4
304	298-583	1.09-2.1	6
306	582	2.1	7
316	296-581	1.09-2.1	8
323	583	2.1	8
329	298-582	1.09-2.1	11
331	302-583	1.10-2.1	15
333	582	2.1	17
342	360-581	1.32-2.1	16
350	360-582	1.31-2.1	52
413	226-601	0.85-2.2	33
454	228-602	0.84-2.2	33
523	220-440	0.84-1.7	54
552	300-440	1.1-1.7	76

NOTES:

1. Run numbers < 200 from Ref. 1; Run numbers <300 from Ref. 2; Run numbers < 400 from Ref. 3; Run numbers < 500 from Ref. 4; Run numbers > 500 are present test data.
2. Hot-wire probes were numbered independently for each of the five test programs represented in this table. For example, Hot-Wire No. 6 for RUN 6 was not the same sensor as that used for RUN 304.

TABLE 3. Concluded

g. Hot-wire identification

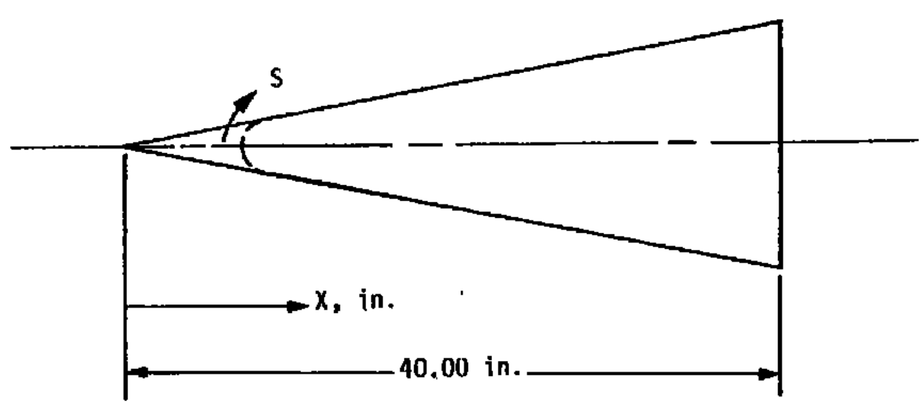
Hot-Wire No.	RUN No.	Wire Diameter
6	6	20 μ-in.
7	7-51	
8	52-71	
14	77-79	
15	80-91	
17	92-100	
3	114-121	
2	126-128	
1	133-136	
16	137-142	
HF-4	207-208	
31	209-225	20 μ-in.
33	226-239,250-285	
39	242	
40	243-249	
4	301	20 μ-in.
6	304	
7	306-311	
8	316,318-321,323	
11	324-329	
15	331-332	
17	333-338	
16	342,344-349	
52	350-357,359-378	50 μ-in.
33	414-427,432-447 455,460-470,473-476	20 μ-in.
54	523	20 μ-in.
76	551,552,555-559 561-563,566-576	50 μ-in.
71	585	50 μ-in.
74	588-590	50 μ-in.
177	597	50 μ-in.
73	610-616	50 μ-in.

NOTES:
1. Run numbers <200 from Ref. 1, Run numbers <300 from Ref. 2; Run numbers <400 from Ref. 3; Run numbers <500 from Ref. 4; Run numbers >500 are present test data.
2. A hot-film probe was used for RUNS 207-208 (HF-4)
3. Hot-wire probes were numbered indenpendently for each of the five test programs represented in this table. For example, Hot-Wire No.6 for RUN 6 was not the same sensor as that used for RUN 304.

TABLE 4. Stations for Mean-Flow Surveys

X(STATION)	S,in.						
RN,in.	0.0015	0.15	0.25	0.50	0.70	0.90	2.00
6	6.00*						
10	10.07	9.08	8.40	6.73			
11	11.18						
14	14.10	13.11					
15	15.10,14.93*	14.11		11.76			
16							2.73
17	17.12	16.13		13.78			
18	18.08						
19				15.95			
20	20.14	19.15					
24	24.01*						
25	25.18	24.19	23.51	21.84		19.16	11.80
26					21.51		
27	27.19	26.20					
28	28.20						
30	30.22	29.23	28.55				
31					26.55		
32	32.23						
33	33.24	32.25					
34	34.25						
35	35.25	34.26	33.59	31.91			21.87
36	36.26						
37	37.27	36.28			32.59		

* Indicates present test data.



APPENDIX III

SAMPLE DATA

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVI[illegible]N
VON KARMA[illegible] [illegible]S DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 13-FEB-85
DATE RECORDED 13- [illegible] -85
TIME RECORDED 2[illegible]:[illegible]18
TIME COMPUTED 02:46
PROJECT NO V [illegible]-0G

RUN NUMBER 551 PAGE 1

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 13.00

DATA TYPE 9
HOT WIRE ANEMOMETER DATA

POINT	CURRENT (MAMP)	EBAR (MV)	ERMS (MV)	XC (IN.)	PT (PSIA)	TT (DEG R)	P (PSIA)	Q (PSIA)	T (DEG R)	RE	ZA (IN.)
1	0.003	0.00	535.78	0.00	4.403E+02	1.312E+03	4.597E-02	2.047E+00	9.556E+01	1.671E+05	8.120E-03
2	0.511	23.91	537.12	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.020E-03
3	1.030	48.57	541.17	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.020E-03
4	1.603	75.96	554.18	0.00	4.405E+02	1.312E+03	4.599E-02	2.048E+00	9.556E+01	1.672E+05	8.020E-03
5	2.007	95.55	555.37	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.120E-03
6	2.488	119.30	563.26	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.020E-03
7	3.037	146.96	572.74	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.219E-03
8	3.510	171.50	579.09	0.00	4.407E+02	1.312E+03	4.601E-02	2.049E+00	9.556E+01	1.673E+05	8.120E-03
9	3.900	192.38	585.36	0.00	4.406E+02	1.312E+03	4.600E-02	2.049E+00	9.556E+01	1.673E+05	8.120E-03
10	4.276	213.09	591.08	0.00	4.408E+02	1.312E+03	4.602E-02	2.050E+00	9.556E+01	1.673E+05	8.020E-03
11	4.684	236.31	597.84	0.00	4.407E+02	1.312E+03	4.601E-02	2.049E+00	9.556E+01	1.673E+05	8.020E-03
12	4.997	254.55	602.94	0.00	4.404E+02	1.312E+03	4.598E-02	2.048E+00	9.556E+01	1.672E+05	8.219E-03

ALPHA = 0.00

RUN NUMBER 551

Sample 1. Hot-wire anemometer data (Type 9)

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVIS N
VON KARMAN GS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 13-FEB-85
DATE RECORDED 13- -85
TIME RECORDED 2: :18
TIME COMPUTED 02:46
PROJECT NO V B-UG

RUN NUMBER 551 PAGE 2

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 13.00

DATA TYPE 9
HOT WIRE ANEMOMETER DATA

POINT	PT (PSIA)	TT (DEG R)	PWL (PSIA)	TWL (DEG R)	ZP (IN)	PP (PSIA)	ML	TT1U/TT	TTL/TT
1	4.403E+02	1.312E+03	6.177E-03	8.621E+02	2.300E-02	3.861E+00	2.2024E+01	9.365E-01	1.000E+00
2	4.406E+02	1.312E+03	6.177E-03	8.651E+02	2.300E-02	3.865E+00	2.2036E+01	9.370E-01	1.000E+00
3	4.406E+02	1.312E+03	6.177E-03	8.667E+02	2.300E-02	3.866E+00	2.2039E+01	9.370E-01	1.000E+00
4	4.405E+02	1.312E+03	6.177E-03	8.684E+02	2.300E-02	3.866E+00	2.2039E+01	9.174E-01	1.000E+00
5	4.406E+02	1.312E+03	6.177E-03	8.700E+02	2.300E-02	3.870E+00	2.2050E+01	9.371E-01	1.000E+00
6	4.406E+02	1.312E+03	6.177E-03	8.720E+02	2.300E-02	3.870E+00	2.2050E+01	9.371E-01	1.000E+00
7	4.406E+02	1.312E+03	6.177E-03	8.748E+02	2.300E-02	3.871E+00	2.2053E+01	9.372E-01	1.000E+00
8	4.407E+02	1.312E+03	6.177E-03	8.753E+02	2.300E-02	3.870E+00	2.2050E+01	9.373E-01	1.000E+00
9	4.406E+02	1.312E+03	6.177E-03	8.779E+02	2.300E-02	3.870E+00	2.2050E+01	9.370E-01	1.000E+00
10	4.408E+02	1.312E+03	6.177E-03	8.794E+02	2.300E-02	3.872E+00	2.2056E+01	9.370E-01	1.000E+00
11	4.407E+02	1.312E+03	6.177E-03	8.810E+02	2.300E-02	3.871E+00	2.2053E+01	9.370E-01	1.000E+00
12	4.404E+02	1.312E+03	6.177E-03	8.828E+02	2.300E-02	3.871E+00	2.2053E+01	9.370E-01	1.000E+00

ALPHA = 0.00

M = 7.977

RUN NUMBER 551

Sample 1. Concluded

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 1 [illegible] FEB-85
DATE RECORDED 13-FEB-85
TIME RECORDED 2:13:18
TIME COMPUTED 02:36
PROJECT NO V B-0G

RUN NUMBER 552 PAGE 1

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 13.00 IN.

DATA TYPE: 6, PROBE FLOW CALIBRATION

POINT	M	PT (PSIA)	TT (DEG R)	RE	PP (PSIA)	ML	TTTU (DEG R)	TTTU/TT	ETA	RETD**.5
1	7.97	398.44	1311.67	1.515E+05	3.5144	7.9320	1228.1384	0.9363	0.9313	9.043E+00
2	7.97	398.44	1311.67	1.515E+05	3.5144	7.9320	1228.1384	0.9363	0.9313	9.043E+00
3	7.96	348.84	1312.67	1.329E+05	3.0841	7.9279	1228.5556	0.9359	0.9309	8.480E+00
4	7.96	348.84	1312.67	1.329E+05	3.0841	7.9279	1228.4515	0.9358	0.9308	8.480E+00
5	7.95	298.94	1311.67	1.143E+05	2.6476	7.9248	1227.3076	0.9357	0.9306	7.878E+00
6	7.95	298.94	1311.67	1.143E+05	2.6496	7.9234	1227.1344	0.9356	0.9305	7.877E+00
7	7.98	438.74	1309.67	1.669E+05	3.8542	7.9391	1226.5072	0.9365	0.9315	9.480E+00
8	7.98	438.84	1309.67	1.670E+05	3.8552	7.9391	1226.6983	0.9366	0.9317	9.481E+00

RUN NUMBER 552

Sample 2. Probe flow calibration (Type 6)

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISI
VON KARMAN . , DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 23-APR-85
DATE RECORDED 15-FI 5
TIME RECORDED 5:54:26
TIME COMPUTED 22:42
PROJECT NO V B-0G

RUN NUMBER 603 PAGE 1

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 24.00 IN.

DATA TYPE 4
FLOW FIELD SURVEYS

POINT	PT (PSIA)	TT (DEG R)	PT2 (PSIA)	P (PSIA)	ZP (IN)	PP (PSIA)	PWL (PSIA)	TWL (DEG R)	ZT (IN)	TTTU (DEG R)	ZA (IN)	TTA DEG R)	MA	LRETA
1	439.90	1309.7	3.783	0.046	0.0150	0.205	0.123	1098.5	0.0176	1167.8	0.0176	1171.5	9.03E-01	1.788E+03
2	440.10	1309.7	3.785	0.046	0.0420	0.312	0.123	1099.2	0.0446	1162.6	0.0446	1183.8	1.31E+00	2.772E+03
3	439.90	1310.7	3.783	0.046	0.0508	0.408	0.123	1097.4	0.0534	1168.7	0.0534	1195.8	1.56E+00	3.423E+03
4	439.80	1309.7	3.782	0.046	0.0615	0.590	0.123	1098.0	0.0641	1180.3	0.0641	1216.3	1.93E+00	4.530E+03
5	439.80	1309.7	3.782	0.046	0.0716	0.868	0.123	1098.2	0.0742	1194.5	0.0742	1240.7	2.39E+00	6.071E+03
6	439.90	1309.7	3.783	0.046	0.0814	1.286	0.123	1098.7	0.0840	1212.9	0.0840	1268.9	2.95E+00	8.250E+03
7	439.80	1309.7	3.782	0.046	0.0909	1.914	0.123	1097.9	0.0935	1230.4	0.0935	1295.6	3.61E+00	1.131E+04
8	439.80	1309.7	3.782	0.046	0.1015	2.855	0.123	1098.0	0.1041	1247.1	0.1041	1320.1	4.41E+00	1.572E+04
9	439.90	1309.7	3.783	0.046	0.1120	4.069	0.123	1098.0	0.1146	1254.2	0.1146	1332.6	5.25E+00	2.140E+04
10	439.80	1309.7	3.782	0.046	0.1215	5.433	0.123	1098.7	0.1240	1248.8	0.1240	1330.2	6.02E+00	2.767E+04
11	439.60	1309.7	3.782	0.046	0.1315	6.764	0.123	1097.9	0.1340	1238.5	0.1340	1321.3	6.61E+00	3.343E+04
12	439.70	1309.7	3.782	0.046	0.1414	7.434	0.123	1097.9	0.1439	1232.0	0.1439	1314.8	6.87E+00	3.548E+04
13	439.60	1310.7	3.781	0.046	0.1467	7.551	0.123	1097.1	0.1492	1229.9	0.1492	1312.6	6.90E+00	3.610E+04
14	439.50	1310.7	3.780	0.046	0.1514	7.575	0.123	1097.3	0.1539	1229.0	0.1539	1311.6	6.91E+00	3.644E+04
15	439.40	1310.7	3.779	0.046	0.1562	7.589	0.123	1097.1	0.1587	1226.4	0.1587	1310.9	6.90E+00	3.642E+04
16	439.40	1310.7	3.779	0.046	0.1613	7.554	0.123	1097.0	0.1638	1227.6	0.1638	1310.2	6.89E+00	3.628E+04
17	439.50	1310.7	3.780	0.046	0.1666	7.540	0.123	1097.1	0.1691	1227.4	0.1691	1309.9	6.88E+00	3.625E+04
18	440.10	1310.7	3.785	0.046	0.1704	7.531	0.123	1097.0	0.1729	1227.6	0.1729	1309.9	6.88E+00	3.619E+04
19	440.10	1309.7	3.785	0.046	0.1757	7.512	0.123	1097.8	0.1782	1227.5	0.1782	1309.9	6.87E+00	3.613E+04
20	440.50	1309.7	3.788	0.046	0.1811	7.513	0.123	1098.0	0.1836	1227.1	0.1836	1309.6	6.87E+00	3.615E+04
21	440.60	1309.7	3.789	0.046	0.1867	7.506	0.123	1097.9	0.1892	1227.2	0.1892	1309.6	6.87E+00	3.611E+04
22	440.70	1309.7	3.790	0.046	0.1917	7.501	0.123	1098.1	0.1942	1226.8	0.1942	1309.3	6.87E+00	3.611E+04
23	440.50	1309.7	3.788	0.046	0.2016	7.503	0.123	1096.1	0.2041	1226.8	0.2041	1309.7	6.87E+00	3.613E+04
24	440.60	1309.7	3.791	0.046	0.2111	7.506	0.123	1097.9	0.2136	1226.8	0.2136	1309.2	6.87E+00	3.614E+04
25	440.90	1309.7	3.792	0.046	0.2214	7.506	0.123	1099.0	0.2239	1226.9	0.2239	1309.3	6.87E+00	3.614E+04
26	440.90	1309.7	3.792	0.046	0.2315	7.505	0.123	1098.9	0.2340	1226.9	0.2340	1309.3	6.87E+00	3.613E+04
27	440.70	1309.7	3.790	0.046	0.2417	7.505	0.123	1098.9	0.2441	1227.0	0.2441	1309.4	6.87E+00	3.612E+04
28	440.80	1309.7	3.791	0.046	0.2611	7.505	0.123	1098.0	0.2635	1227.1	0.2635	1309.5	6.87E+00	3.612E+04
29	441.10	1310.7	3.793	0.046	0.2812	7.500	0.123	1096.2	0.2836	1226.5	0.2836	1308.9	6.87E+00	3.612E+04
30	441.10	1309.7	3.793	0.046	0.3009	7.499	0.123	1097.9	0.3033	1226.8	0.3033	1309.1	6.87E+00	3.610E+04
31	440.70	1309.7	3.790	0.046	0.3209	7.486	0.123	1097.8	0.3233	1227.0	0.3233	1309.4	6.86E+00	3.603E+04
32	440.60	1309.7	3.791	0.046	0.3411	7.485	0.123	1098.9	0.3435	1226.7	0.3435	1309.1	6.86E+00	3.604E+04
33	440.90	1309.7	3.792	0.046	0.3610	7.476	0.123	1097.6	0.3634	1226.6	0.3634	1308.9	6.86E+00	3.600E+04
34	441.00	1309.7	3.792	0.046	0.3811	7.471	0.123	1097.8	0.3834	1226.8	0.3834	1309.2	6.85E+00	3.597E+04
35	441.00	1309.7	3.792	0.046	0.4013	7.468	0.123	1097.9	0.4036	1226.8	0.4036	1309.1	6.85E+00	3.596E+04

MEAN VALUES

PHI = -109.9 DEG		PT =	440.3	PSIA	P =	0.0460	PSIA
M =	7.98	TT =	1309.9	DEG R	PWL =	0.123	PSIA
ALPHA =	-0.0	PT2 =	3.786	PSIA	TWL =	1098.2	DEG R
DEW =	-69.	RE =	1.675E+05	PER IN	V =	3820.1	FT/SEC
		MU =	7.680E-08	LBF-SEC/FT2	Q =	2.047	PSIA
		RHO =	4.965E+00	LBM/FT3	T =	95.4	DEG R

RUN NUMBER 603

Sample 3. Flow-field survey data (Type 4)

ARVIN/CALSPAN FIELD SERVICES,INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 23-APR-85
DATE RECORDED 15-[illegible]-85
TIME RECORDED 5:54:26
TIME COMPUTED 22:42
PROJECT NO V [illegible]-0G

RUN NUMBER 603 PAGE 2

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 24.00 IN.

DATA TYPE 4
FLOW FIELD SURVEYS

POINT	ZP (IN)	PP/PPE	ML	ML/ME	TTLD (DEG R)	TTL (DEG R)	TTL/TTE	TL (DEG R)	UL (FT/SEC)	UL/UE	LRE	LRET	ERMS
1	0.0150	0.028	6.91E-01	0.130	1161.1	1172.3	0.895	1011.6	1.390E+03	0.369	1.951E+03	1.771E+03	2.8899E+02
2	0.0420	0.047	1.25E+00	0.182	1161.5	1181.0	0.902	901.0	1.834E+03	0.486	3.124E+03	2.612E+03	2.8891E+02
3	0.0508	0.055	1.48E+00	0.216	1166.6	1191.6	0.910	829.8	2.086E+03	0.553	4.067E+03	3.206E+03	2.8871E+02
4	0.0615	0.079	1.83E+00	0.267	1177.0	1210.8	0.925	724.7	2.417E+03	0.641	5.959E+03	4.212E+03	2.8873E+02
5	0.0716	0.115	2.26E+00	0.330	1190.4	1233.9	0.942	609.2	2.740E+03	0.727	9.121E+03	5.611E+03	2.8902E+02
6	0.0814	0.172	2.79E+00	0.407	1208.1	1261.6	0.964	493.6	3.038E+03	0.806	1.467E+04	7.571E+03	2.8882E+02
7	0.0909	0.256	3.43E+00	0.501	1225.9	1288.8	0.984	384.4	3.297E+03	0.874	2.504E+04	1.041E+04	2.8903E+02
8	0.1015	0.382	4.21E+00	0.614	1213.9	1315.3	1.005	289.4	3.511E+03	0.931	4.539E+04	1.453E+04	2.8889E+02
9	0.1120	0.545	5.04E+00	0.736	1253.8	1331.2	1.017	218.8	3.656E+03	0.970	8.135E+04	1.987E+04	2.8888E+02
10	0.1215	0.728	5.84E+00	0.852	1250.7	1331.5	1.017	170.4	3.735E+03	0.991	1.369E+05	2.606E+04	2.8882E+02
11	0.1315	0.906	6.52E+00	0.951	1240.8	1323.2	1.011	134.3	3.772E+03	1.000	2.070E+05	3.232E+04	2.8862E+02
12	0.1414	0.995	6.84E+00	0.998	1233.4	1316.1	1.005	127.2	3.780E+03	1.002	2.488E+05	3.559E+04	2.8876E+02
13	0.1467	1.011	6.89E+00	1.006	1230.6	1313.5	1.003	125.1	3.779E+03	1.002	2.570E+05	3.621E+04	2.8885E+02
14	0.1514	1.014	6.90E+00	1.007	1229.4	1312.0	1.002	124.6	3.777E+03	1.002	2.569E+05	3.637E+04	2.8885E+02
15	0.1562	1.016	6.91E+00	1.008	1228.7	1311.3	1.002	124.3	3.777E+03	1.002	2.601E+05	3.646E+04	2.8885E+02
16	0.1613	1.011	6.89E+00	1.006	1227.9	1310.5	1.001	124.8	3.774E+03	1.001	2.580E+05	3.632E+04	2.8867E+02
17	0.1660	1.010	6.89E+00	1.005	1227.4	1309.9	1.001	125.0	3.773E+03	1.001	2.573E+05	3.627E+04	2.8837E+02
18	0.1704	1.008	6.88E+00	1.004	1227.4	1309.9	1.001	125.1	3.773E+03	1.001	2.567E+05	3.623E+04	2.8840E+02
19	0.1757	1.006	6.87E+00	1.003	1227.6	1310.0	1.001	125.4	3.773E+03	1.001	2.555E+05	3.614E+04	2.8876E+02
20	0.1811	1.006	6.87E+00	1.003	1227.2	1309.6	1.000	125.3	3.772E+03	1.000	2.557E+05	3.615E+04	2.8871E+02
21	0.1867	1.005	6.87E+00	1.003	1227.3	1309.7	1.000	125.5	3.772E+03	1.000	2.552E+05	3.612E+04	2.8845E+02
22	0.1917	1.004	6.87E+00	1.002	1227.0	1309.4	1.000	125.5	3.772E+03	1.000	2.550E+05	3.611E+04	2.8865E+02
23	0.2016	1.005	6.87E+00	1.002	1226.8	1309.2	1.000	125.5	3.771E+03	1.000	2.552E+05	3.612E+04	2.8868E+02
24	0.2111	1.005	6.87E+00	1.003	1226.8	1309.2	1.000	125.4	3.772E+03	1.000	2.554E+05	3.614E+04	2.8862E+02
25	0.2214	1.005	6.87E+00	1.003	1226.9	1309.3	1.000	125.4	3.772E+03	1.000	2.554E+05	3.614E+04	2.8854E+02
26	0.2315	1.005	6.87E+00	1.002	1226.9	1309.3	1.000	125.4	3.772E+03	1.000	2.553E+05	3.613E+04	2.8840E+02
27	0.2417	1.005	6.87E+00	1.002	1227.0	1309.4	1.000	125.4	3.772E+03	1.000	2.552E+05	3.612E+04	2.8837E+02
28	0.2611	1.005	6.87E+00	1.002	1227.1	1309.6	1.000	125.5	3.772E+03	1.000	2.552E+05	3.612E+04	2.8845E+02
29	0.2812	1.004	6.87E+00	1.002	1226.5	1308.9	1.000	125.5	3.771E+03	1.000	2.551E+05	3.612E+04	2.8884E+02
30	0.3009	1.004	6.87E+00	1.002	1226.7	1309.1	1.000	125.5	3.771E+03	1.000	2.549E+05	3.611E+04	2.8872E+02
31	0.3209	1.002	6.86E+00	1.001	1227.0	1309.4	1.000	125.7	3.771E+03	1.000	2.540E+05	3.604E+04	2.8834E+02
32	0.3411	1.002	6.86E+00	1.001	1226.8	1309.1	1.000	125.7	3.771E+03	1.000	2.540E+05	3.604E+04	2.8826E+02
33	0.3610	1.001	6.86E+00	1.001	1226.6	1308.9	1.000	125.8	3.770E+03	1.000	2.535E+05	3.601E+04	2.8884E+02
34	0.3811	1.000	6.85E+00	1.000	1226.8	1309.2	1.000	125.9	3.771E+03	1.000	2.531E+05	3.597E+04	2.8851E+02
35	0.4013	1.000	6.85E+00	1.000	1226.8	1309.2	1.000	126.0	3.771E+03	1.000	2.530E+05	3.596E+04	2.8870E+02

MEAN VALUES

PHI =-109.9 DEG
M = 7.98
ALPHA= -0.0 DEG

PT = 440.3 PSIA
TT =1309.9 DEG R
P = 0.0460 PSIA
T = 95.4 DEG R

TWL/TTE = 0.8388
PWL = 0.172 PSIA
TWL =1098.2 DEG R

EDGE VALUES

PPE = 7.468E+00 PSIA
ME = 6.852E+00
TTE = 1.309E+03 DEG R
UE = 0.377E+04 FT/SEC

RUN NUMBER 603

Sample 3. Continued

ARVIN/CALSPAN FIELD SERVICES,INC.
AEDC DIVIS'
VON KARMAN 3 DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 23-AP"-85
DATE RECORDED 15-F 85
TIME RECORDED 5:54:26
TIME COMPUTED 22:42
PROJECT NO V B-0G

RUN NUMBER 603 PAGE 3

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 24.00 IN.

DATA TYPE 4
MODEL SURFACE MEASUREMENTS

TAP	S (IN)	THETA (DEG)	PW (PSIA)	SD PW (PSI)	PW/P
1	39.790	0	0.1259	0.0001	2.7596
2	38.790	0	0.1283	0.0002	2.7596
3	38.290	0	0.1342	0.0002	2.7596
4	36.230	0	0.1256	0.0002	2.7596
5	34.290	0	0.1242	0.0002	2.7596
7	30.230	0	0.1286	0.0002	2.7596
8	28.230	0	0.1278	0.0003	2.7596
9	26.230	0	0.1258	0.0003	2.7596
10	24.230	0	0.1151	-0.0004	2.7596
11	27.230	0	0.1175	0.0002	2.7596
12	20.140	0	0.1113	0.0002	2.7596
13	17.140	0	0.1228	0.0001	2.7596
14	15.140	0	0.1191	0.0002	2.7596
15	13.140	0	0.1113	0.0002	2.7596
16	11.140	0			
17	9.140	0	0.1296	0.0002	2.7596
18	8.110	0	0.1315	0.0002	2.7596
19	11.140	270	0.1272	0.0001	2.7596
20	11.110	180	0.1299	0.0002	-2.7596
21	30.230	270	0.1354	0.0005	2.7596
22	30.230	180	0.1301	0.0001	2.7596
23	39.790	270	0.1301	0.0002	2.7596
24	39.790	180	0.1406	0.0012	2.7596
25	27.230	180	0.1183	0.0002	2.7596

T/C	S (IN)	THETA (DEG)	TW (DEG R)	SD TW (DEG R)	TW/TT
1	38.790	180			
2	38.290	180	1004.3	0.22	0.767
3	37.590	180	1021.0	0.31	0.779
4	36.290	180	1035.7	0.43	0.791
5	35.290	180	1047.1	0.55	0.799
6	34.290	180	1053.3	0.68	0.804
7	33.290	180	1059.6	0.83	0.809
8	32.230	180	1069.4	1.00	0.816
9	31.230	180	1078.6	1.17	0.823
10	29.930	180	1083.9	1.18	0.827
11	29.230	180	1091.6	1.26	0.833
12	28.230	180	1096.0	1.23	0.837
13	27.230	180	1093.2	1.08	0.835
14	26.230	180	1096.9	0.72	0.837
15	25.230	180	1097.1	0.48	0.838
16	24.230	180	1098.2	0.44	0.838
17	23.230	180	1099.6	0.62	0.839
19	21.140	180	1101.6	1.47	0.841
20	20.140	180	1099.5	1.69	0.839
21	19.140	180			
22	18.140	180			
23	17.140	180	1088.5	1.97	0.831
25	15.140	180	1078.5	1.85	0.823
26	14.140	180	1075.6	1.73	0.821
27	13.140	180	1072.8	1.61	0.819
28	12.140	180	1070.0	1.52	0.817
29	10.840	180	1061.8	1.41	0.811
30	10.140	180			
31	9.140	180			
32	8.140	180			

THE VALUES OF THE FOLLOWING THERMOCOUPLES HAVE BEEN INTERPOLATED 4 6 8 26 27

MEAN VALUES

PHI =-109.9 DEG PT = 440.3 PSIA TORK = 507.7 DEG R
M = 7.98 TT =1309.9 DEG R
ALPHA = -0.0 DEG P = 0.0460 PSIA T = 95.4 DEG R
XC = 2.402E+01

RUN NUMBER 603

Sample 3. Continued

CONFIG: SHARP 7-DEG CONE (RN = 0.0015 IN.)
XSTA = 24.00 IN.

DATA TYPE 4
INTEGRAL EVALUATION

POINT	ZP/DEL	PP/PPD	ML/MD	TTL/TTD	TL/TD	RHOL/RHOD	UL/UD	MUTL/MUTD	LPE/LPED	DITTL/DITTD	LRET/LRETD
1	3.736E-02	2.750E-02	1.301E-01	8.955E-01	8.029E+00	1.245E-01	3.686E-01	5.953E+00	7.711E-03	3.469E-01	4.926E-02
2	1.017E-01	4.179E-02	1.619E-01	9.021E-01	7.157E+00	1.398E-01	4.864E-01	5.507E+00	1.235E-02	3.848E-01	7.264E-02
3	1.266E-01	5.461E-02	2.155E-01	9.103E-01	6.586E+00	1.518E-01	5.531E-01	5.204E+00	1.614E-02	4.400E-01	8.916E-02
4	1.533E-01	7.904E-02	2.673E-01	9.249E-01	5.752E+00	1.739E-01	6.410E-01	4.731E+00	2.356E-02	5.314E-01	1.171E-01
5	1.703E-01	1.163E-01	3.304E-01	9.425E-01	4.835E+00	2.068E-01	7.266E-01	4.168E+00	3.605E-02	6.399E-01	1.560E-01
6	2.078E-01	1.732E-01	4.070E-01	9.636E-01	3.918E+00	2.553E-01	8.057E-01	3.547E+00	5.798E-02	7.692E-01	2.105E-01
7	2.265E-01	2.563E-01	5.605E-01	9.845E-01	3.051E+00	3.277E-01	8.743E-01	2.845E+00	9.900E-02	9.029E-01	2.894E-01
8	2.579E-01	3.822E-01	6.144E-01	1.005E+00	2.297E+00	4.353E-01	9.312E-01	2.259E+00	1.794E-01	1.029E+00	4.042E-01
9	2.791E-01	5.449E-01	7.358E-01	1.017E+00	1.737E+00	5.758E-01	9.696E-01	1.736E+00	3.216E-01	1.106E+00	5.575E-01
10	3.078E-01	7.275E-01	8.517E-01	1.017E+00	1.353E+00	7.392E-01	9.906E-01	1.353E+00	5.413E-01	1.103E+00	7.745E-01
11	3.277E-01	9.057E-01	9.513E-01	1.013E+00	1.106E+00	9.045E-01	1.000E+00	1.106E+00	8.183E-01	1.067E+00	8.987E-01
12	3.524E-01	9.955E-01	9.977E-01	1.005E+00	1.009E+00	9.906E-01	1.002E+00	1.009E+00	9.837E-01	1.034E+00	9.897E-01
13	3.656E-01	1.011E+00	1.006E+00	1.003E+00	9.933E-01	1.007E+00	1.002E+00	9.913E-01	1.016E+00	1.021E+00	1.007E+00
14	3.773E-01	1.014E+00	1.007E+00	1.002E+00	9.893E-01	1.011E+00	1.002E+00	9.843E-01	1.024E+00	1.013E+00	1.011E+00
15	3.892E-01	1.016E+00	1.008E+00	1.002E+00	9.870E-01	1.013E+00	1.002E+00	9.870E-01	1.028E+00	1.010E+00	1.014E+00
16	4.019E-01	1.011E+00	1.006E+00	1.001E+00	9.906E-01	1.009E+00	1.001E+00	9.906E-01	1.020E+00	1.007E+00	1.010E+00
17	4.152E-01	1.010E+00	1.005E+00	1.001E+00	9.919E-01	1.008E+00	1.001E+00	9.919E-01	1.017E+00	1.004E+00	1.009E+00
18	4.246E-01	1.008E+00	1.004E+00	1.001E+00	9.929E-01	1.007E+00	1.001E+00	9.929E-01	1.015E+00	1.004E+00	1.007E+00
19	4.378E-01	1.006E+00	1.003E+00	1.001E+00	9.953E-01	1.005E+00	1.001E+00	9.953E-01	1.010E+00	1.005E+00	1.005E+00
20	4.513E-01	1.006E+00	1.003E+00	1.000E+00	9.949E-01	1.005E+00	1.000E+00	9.949E-01	1.011E+00	1.002E+00	1.005E+00
21	4.652E-01	1.005E+00	1.003E+00	1.000E+00	9.958E-01	1.004E+00	1.000E+00	9.958E-01	1.009E+00	1.003E+00	1.004E+00
22	4.777E-01	1.004E+00	1.002E+00	1.000E+00	9.962E-01	1.004E+00	1.000E+00	9.962E-01	1.008E+00	1.000E+00	1.004E+00
23	5.024E-01	1.005E+00	1.002E+00	1.000E+00	9.958E-01	1.004E+00	1.000E+00	9.958E-01	1.009E+00	9.996E-01	1.004E+00
24	5.260E-01	1.005E+00	1.003E+00	1.000E+00	9.954E-01	1.005E+00	1.000E+00	9.954E-01	1.009E+00	1.000E+00	1.005E+00
25	5.517E-01	1.005E+00	1.003E+00	1.000E+00	9.953E-01	1.005E+00	1.000E+00	9.953E-01	1.010E+00	9.960E-01	1.005E+00
26	5.769E-01	1.005E+00	1.002E+00	1.000E+00	9.956E-01	1.004E+00	1.000E+00	9.956E-01	1.009E+00	9.958E-01	1.005E+00
27	6.023E-01	1.005E+00	1.002E+00	1.000E+00	9.957E-01	1.004E+00	1.000E+00	9.957E-01	1.009E+00	9.968E-01	1.005E+00
28	6.506E-01	1.005E+00	1.002E+00	1.000E+00	9.958E-01	1.004E+00	1.000E+00	9.958E-01	1.009E+00	1.002E+00	1.004E+00
29	7.007E-01	1.004E+00	1.002E+00	9.998E-01	9.959E-01	1.004E+00	1.000E+00	9.959E-01	1.008E+00	9.937E-01	1.004E+00
30	7.494E-01	1.004E+00	1.002E+00	1.000E+00	9.962E-01	1.004E+00	1.000E+00	9.962E-01	1.006E+00	1.000E+00	1.005E+00
31	7.997E-01	1.002E+00	1.001E+00	1.000E+00	9.980E-01	1.002E+00	1.000E+00	9.980E-01	1.004E+00	1.002E+00	1.002E+00
32	8.500E-01	1.002E+00	1.001E+00	1.000E+00	9.979E-01	1.002E+00	1.000E+00	9.979E-01	1.004E+00	9.953E-01	1.002E+00
33	8.996E-01	1.001E+00	1.001E+00	9.998E-01	9.988E-01	1.001E+00	1.000E+00	9.988E-01	1.002E+00	1.000E+00	1.001E+00
34	9.497E-01	1.000E+00	1.000E+00	1.000E+00	9.997E-01	1.000E+00	1.000E+00	9.997E-01	1.001E+00	1.001E+00	1.000E+00
35	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00	1.000E+00

VALUES AT DELTA

PHI =-109.9 DEG
M = 7.98
ALPHA = -0.0 DEG

DEL = 4.013E-01 IN
DEL* = 9.904E-02 IN
DEL** = 3.666E-03 IN

LRED = 2.530E+05 PER IN

PPD = 7.468E+00 PSIA
MD = 6.8524E+00
TD = 1.260E+02 DEG R
TTD = 1.309E+03 DEG R
UD = 3.771E+03 FT/SEC

RHOD = 2.626E-03 LBM/FT3
RHOUD = 9.902E+00 LBM/SEC-FT2
MUTD = 1.014E-07 LBF-SEC/FT2
DITTD = 5.407E+01 BTU/LBM
LRETD = 3.596E+04 PER IN

RUN NUMBER 603

Sample 3. Concluded

ARVIN/CALSPAN FIELD SERVICES,INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENN
BOUNDARY LAYER STABILITY INVESTIGATION

DATE COMPUTED 15-[illegible]B-85
DATE RECORDED 15 [illegible]-85
TIME RECORDED 2:19: 9
TIME COMPUTED 02:20
PROJECT NO V B-0[illegible]

RUN NUMBER 591 PAGE 1

CONFIG: SHARP 7-DEG CONE.(RN = 0.0015 IN.)

DATA TYPE 2
MODEL SURFACE MEASUREMENTS

TAP	S (IN)	THETA (DEG)	PW (PSIA)	PW/P
1	39.790	0	0.1896	2.7395
2	38.790	0	0.1891	2.7323
3	38.290	0	0.1993	2.8792
4	36.290	0	0.1893	2.7354
5	34.290	0	0.1866	2.6966
7	30.230	0	0.1985	2.8685
8	28.230	0	0.1974	2.8524
9	26.230	0	0.1969	2.8455
10	24.230	0	0.1833	2.6491
11	22.230	0	0.1856	2.6810
12	20.140	0	0.1802	2.6038
13	17.140	0	0.1903	2.7489
14	15.140	0	0.1830	2.6443
15	13.140	0	0.1798	2.5985
16	11.140	0		
17	9.140	0	0.1944	2.8094
18	8.140	0	0.2032	2.9358
19	11.140	270	0.2032	2.9361
20	11.140	180	0.1946	2.8113
21	30.230	270	0.1959	2.8311
22	30.230	180	0.1989	2.8736
23	39.790	270	0.1928	2.7864
24	39.790	180	0.1886	2.7251
30	22.230	180	0.1894	2.7369

T/C	S (IN)	THETA (DEG)	TW (DEG R)	TW/TT
1	38.790	180		
2	38.290	180	1038.1	0.780
3	37.590	180	1054.5	0.792
4	36.290	180		
5	35.290	180	1078.3	0.810
6	34.290	180		
7	33.290	180	1088.8	0.818
8	32.230	180		
9	31.230	180	1107.1	0.831
10	29.930	180	1112.3	0.835
11	29.230	180	1121.7	0.842
12	28.230	180	1128.6	0.847
13	27.230	180	1129.8	0.848
14	26.230	180	1137.8	0.854
15	25.230	180	1141.5	0.857
16	24.230	180	1145.8	0.860
17	23.230	180	1149.1	0.863
19	21.140	180	1149.6	0.863
20	20.140	180	1147.1	0.861
21	19.140	180	1141.7	0.857
22	18.140	180		
23	17.140	180	1135.3	0.853
24	16.140	180		
30	15.140	180	1125.5	0.845
26	14.140	180		
27	13.140	180		
28	12.140	180	1113.2	0.836
29	10.840	180	1101.0	0.827
30	10.140	180		
31	9.140	180		
32	8.140	180		

TC101 1134.670 TC102 1147.670 TC103 1072.670

PHI =-109.9 DEG
M = 8.0009
ALPHA = 0.0 DEG
DEW = -67.

PT = 676.2 PSIA
TT = 1331.7 DEG R
P = 0.0692 PSIA
RE = 0.249E+06 PER IN
PT2 = 5.736 PSIA

TDRK = 501.7 DEG R

Sample 4. Model surface measurements (Type 2)

RUN NUMBER 591

ARVIN/CALSPAN FIELD SERVICES, INC.
AEDC DIVISION
VON KARMAN GAS DYNAMICS FACILITY
ARNOLD AIR FORCE STATION, TENNESSEE
BOUNDARY LAYER STABILITY INVEST

DATE COMPUTED 3-FEB-85
TIME COMPUTED 01:43:51
DATE RECORDED 13-FEB-84
TIME RECORDED 1:43:23
PROJECT NUMBER V B-0G

RUN NUMBER 550

DATA TYPE: SURFACE HEAT TRANSFER

SHARP 7-DEG CONE (RN=0.0015 IN.)

GAGE NO	S IN	THETA DEG	QDOT BTU/FT2-SEC	TW DEG R	HT(TT) BTU/FT2-SEC-R	ST(TT)
1	38.790	180.000	1.233	586.89	1.704E-03	1.376E-03
2	38.290	180.000	1.185	588.86	1.642E-03	1.326E-03
3	37.590	180.000	1.171	594.08	1.635E-03	1.320E-03
4	36.290	180.000	1.212	600.20	1.707E-03	1.377E-03
5	35.290	180.000	0.915	601.08	1.290E-03	1.041E-03
6	34.290	180.000	1.268	603.75	1.794E-03	1.447E-03
7	33.290	180.000	1.114	606.43	1.582E-03	1.276E-03
8	32.230	180.000	1.363	610.62	1.948E-03	1.571E-03
9	31.230	180.000	1.235	612.15	1.769E-03	1.426E-03
10	29.930	180.000	1.235	612.85	1.770E-03	1.427E-03
11	29.230	180.000	1.436	613.95	2.061E-03	1.662E-03
12	28.230	180.000				
13	27.230	180.000	1.102	613.38	1.581E-03	1.275E-03
14	26.230	180.000	1.311	618.24	1.893E-03	1.526E-03
15	25.230	180.000	1.277	617.65	1.842E-03	1.485E-03
16	24.230	180.000	1.325	616.61	1.910E-03	1.540E-03
17	23.230	180.000	6.913	117.88	5.795E-03	4.802E-03
18						
19	21.140	180.000	1.021	608.37	1.453E-03	1.172E-03
20	20.140	160.000	0.811	604.32	1.148E-03	9.260E-04
21	19.140	180.000	0.941	599.07	1.323E-03	1.067E-03
22	18.140	180.000	0.687	592.64	9.567E-04	7.723E-04
23	17.140	180.000	0.789	589.18	1.093E-03	8.829E-04
24						
25	15.140	180.000	0.573	582.33	7.868E-04	6.355E-04
26	14.140	180.000	0.624	580.27	8.545E-04	6.903E-04
27	13.140	180.000				
28	12.140	180.000	0.405	578.52	5.532E-04	4.469E-04
29	10.840	180.000				
30	10.140	180.000	0.172	576.05	2.336E-04	1.888E-04
31	9.140	180.000	0.475	577.10	6.472E-04	5.229E-04
32	8.140	180.000	0.532	577.23	7.248E-04	5.856E-04

PHI = 0.02 DEG	PT = 440.94 PSIA	V = 3821.19 FT/SEC
M = 7.98	TT = 1310.67 DEG R	Q = 2.050 PSIA
ALPHA = -0.06 DEG	P = 4.603E-02 PSIA	T = 95.49 DEG R
DEW = -155.40 DEG F	RE = 2.011E+06 PER FT	PT2 = 0.01 PSIA
RUN NUMBER 550	MU = 7.684E-08 LBF-SEC/FT	RHO = 1.301E-03 LBM/FT3

Sample 5. Surface heat-transfer data